WATER WORKS & SEWERAGE

L. H. ENSLOW, Editor

LEADING ARTICLES To Appear in the Next and Subsequent Issues:

"Operation and Control of an Industrial Water Supply Reservoir," by P. W. Frisk, Chemical Engineer of the American Enka Corporation, will contain valuable experiences in the successful methods of reservoir operation to insure the highest quality of water for Rayon production and the least costly and difficult to treat in the filtration plant.

Mark B. Owen, Engineer and Superintendent, Public Works, Dearborn, Mich., will report on the operating results from the recently completed sewage treatment works at Dearborn. The process employed is that developed by W. C. Laughlin, president of the Filtration Equipment Corporation, which employs chemical treatment and filtration through an ingenious self-cleansing filter. Sludge is dewatered on vacuum filters and used for fertilizer on Mr. Ford's farm.

B. F. Johnson, Chemist in Charge of Filtration at New Castle, Pa., will write on various measures employed for "Taste and Odor Control" at New Castle, Pa., in which a combination of activated carbon ahead of filtration and use of ammonia beyond the filters has proven the most effective procedure. The distillation method for predicting possible taste and odor development in the mains will be described. Its usefulness in controlling treatment at the plant has been established.

"Sewage Treatment at High Point, N. C.," is the title of an article by E. H. Moss, Superintendent of Plants at High Point, and C. W. Mengel and William C. Olsen, Engineers of Raleigh, N. C., who designed the two sewage treatment plants. The operating results and operating costs will be set forth for the sprinkling filters and separate digestion plant, employing sludge beds, for comparison with the same from the newer activated-sludge plant employing sludge dewatering on vacuum filters.

John R. Baylis will continue his discussion of activated carbon and means of evaluating it for purpose of drawing specifications or comparisons of the efficacy of various carbons on the market.

"A New Method of Concentrating Activated Sludge" will be described in an article by R. F. Goudey, Sanitary Engineer, and S. M. Bennett, Chief Operator, in charge of the Los Angeles Sewage Experimental Station.

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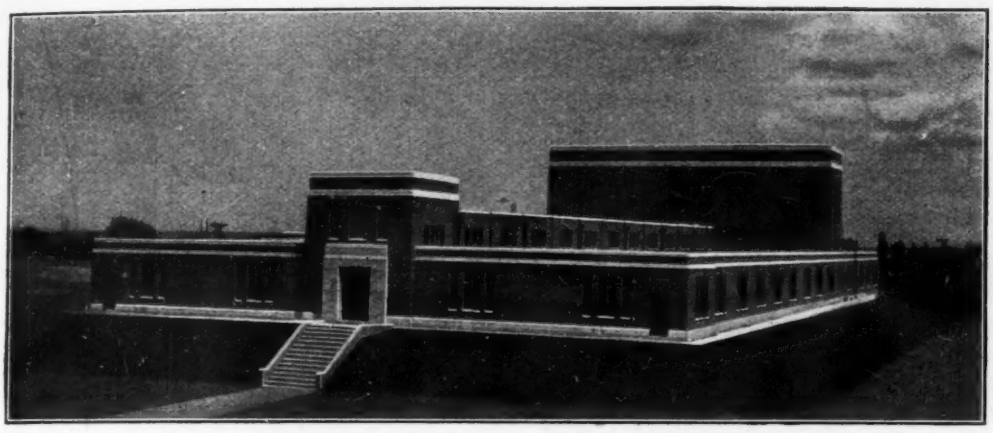

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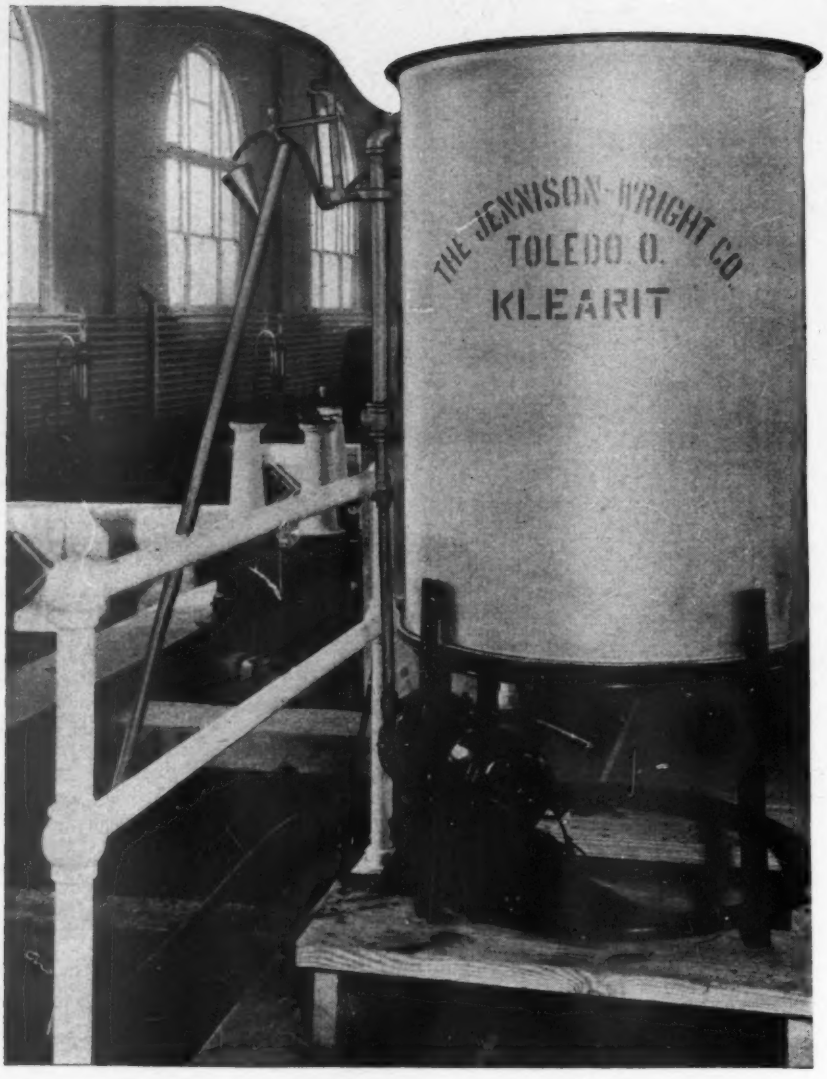

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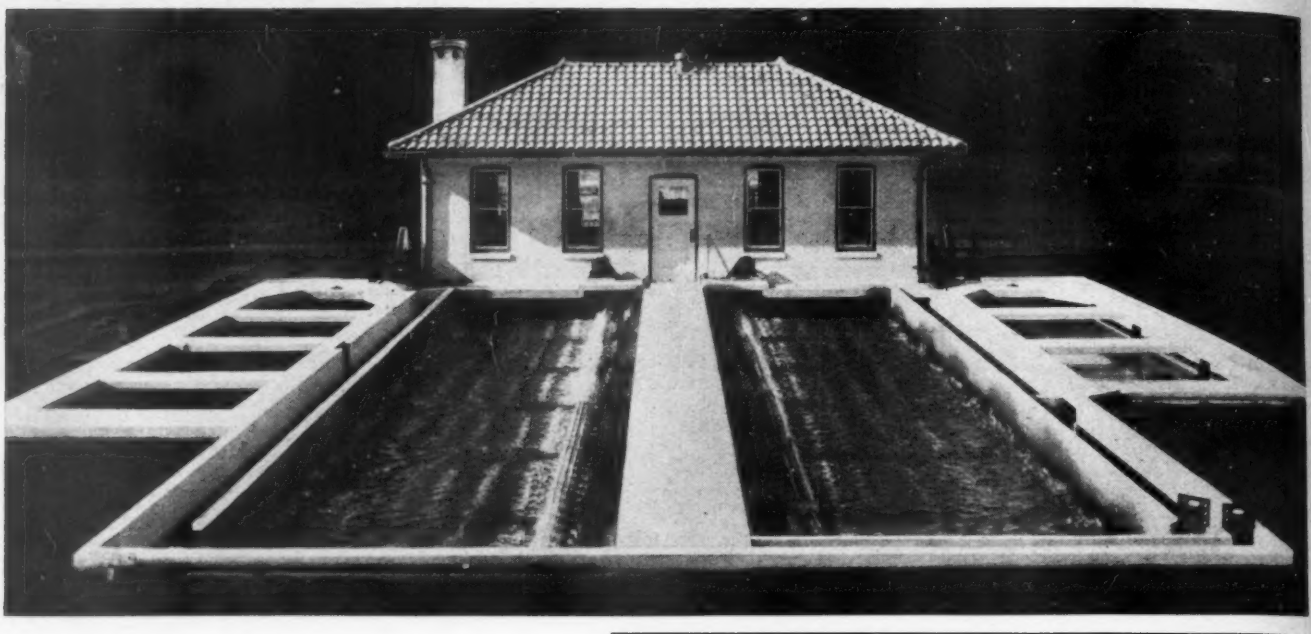

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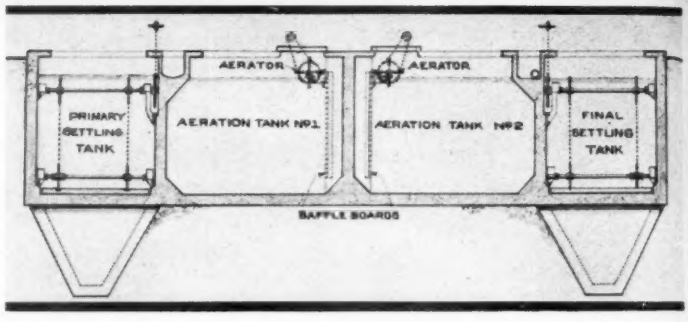
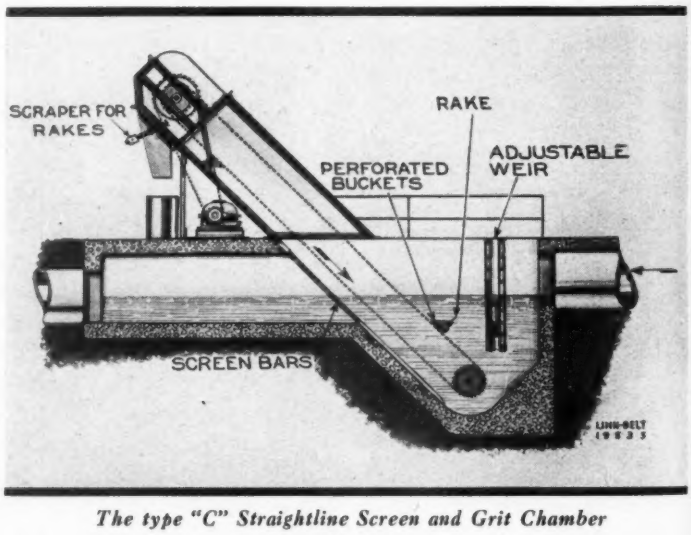


Section of Tanks



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WATER WORKS AND SEWERAGE

SEPT 1932

VOL. 79 No. 9

A GILLETTE PUBLICATION

FERRIC IRON COAGULATION OF SOFT WATER

By EARL C. CRAIG[1] and ELWOOD H. BEAN[2]

ALTHOUGH iron compounds play such an important role in the natural clarification of soft waters the use of iron compounds as coagulants in the treatment of such waters by man has been negligible until very recent times. Two factors have been responsible for this: one is that the cost of aluminum sulphate has been much less than the cost of ferric iron compounds; the other is the fact that alum will produce a floc and clarify waters in the acid state in which they are found; the only iron compound which was known to have this power was ferric chloride and the cost of that was prohibitive. Changes in manufacturing processes within modern times have, however, made available ferric iron salts which are now obtainable at very reasonable prices. Thus, one of the main obstacles to the use of iron compounds has been eliminated.

Properties of iron compounds which used to stand against their use are the very properties which are now desired in a coagulant for soft water. The change has been caused not alone by discovery of new adaptations to water treatment but also by changes in what is demanded of a modern treatment plant, a higher quality of water expected or demanded by the water consumer, whether he be a householder, boiler user, laundry operator, or factory owner. Today, water must not alone be safe and free from color and turbidity, it must also be free from less apparent impurities. Its characteristics, when discharged from the tretment plant, must be such that it will not attack pipes nor develop red water in isolated sections of the distribution system. Neither may there be present any mineral or organic materials which will tend to subsequently precipitate, producing sediment in the pipe system or interfere with manufacturing processes or domestic usage. The first three of these requirements have long been established and may readily be attained with most soft waters if they be coagulated with aluminum sulphate. The later requirements are either difficult or impossible to meet when using this coagulant.

At Providence, Rhode Island, the municipally owned Water Works supplies about 335,000 consumers, located in five cities or towns. The source of the water is known as the Scituate Supply, having a catchment area of 92.8 square miles and capacity of about 85 million gallons daily. The consumption of water at the present time averages about 25 million gallons daily. Principal features of the development include a deepwater impounding reservoir of 37,000 mil. gals. capacity, with 32-ft. avg. and 87-ft. max.-depths; a rapid-sand mechanical filter plant of 48 m.g.d. capacity; high and low service covered distribution reservoirs of 12 m.g. and 40 m.g. capacity, respectively; and about 500 miles of aqueducts and piping. The reservoir water is very soft; has low alkalinity, little turbidity. Bacterial pollution and microscopic organism troubles have not been great so far. Color varies between 15 and 75 parts per million.

The supply was first drawn upon in September, 1926, the water being coagulated with alum and the final effluent receiving a dose of lime to promote stability (noncorrosiveness) of the water in the distribution system, to which incidentally is now connected more than 40,000 lead service pipes. Through 1927, 1928 and 1929 the alum treatment was continued with a gradual reduction in alum dosage to 0.45 of a grain per gallon and gradual increase in final effluent pH from 7.4 to around 8.0. To secure this effect lime was added to the aerated filter effluent.

[1]*Superintendent Scituate Division,* [2]*Chemist in Charge, Filtration Plant, Department of Water Supply, Providence, R. I.*

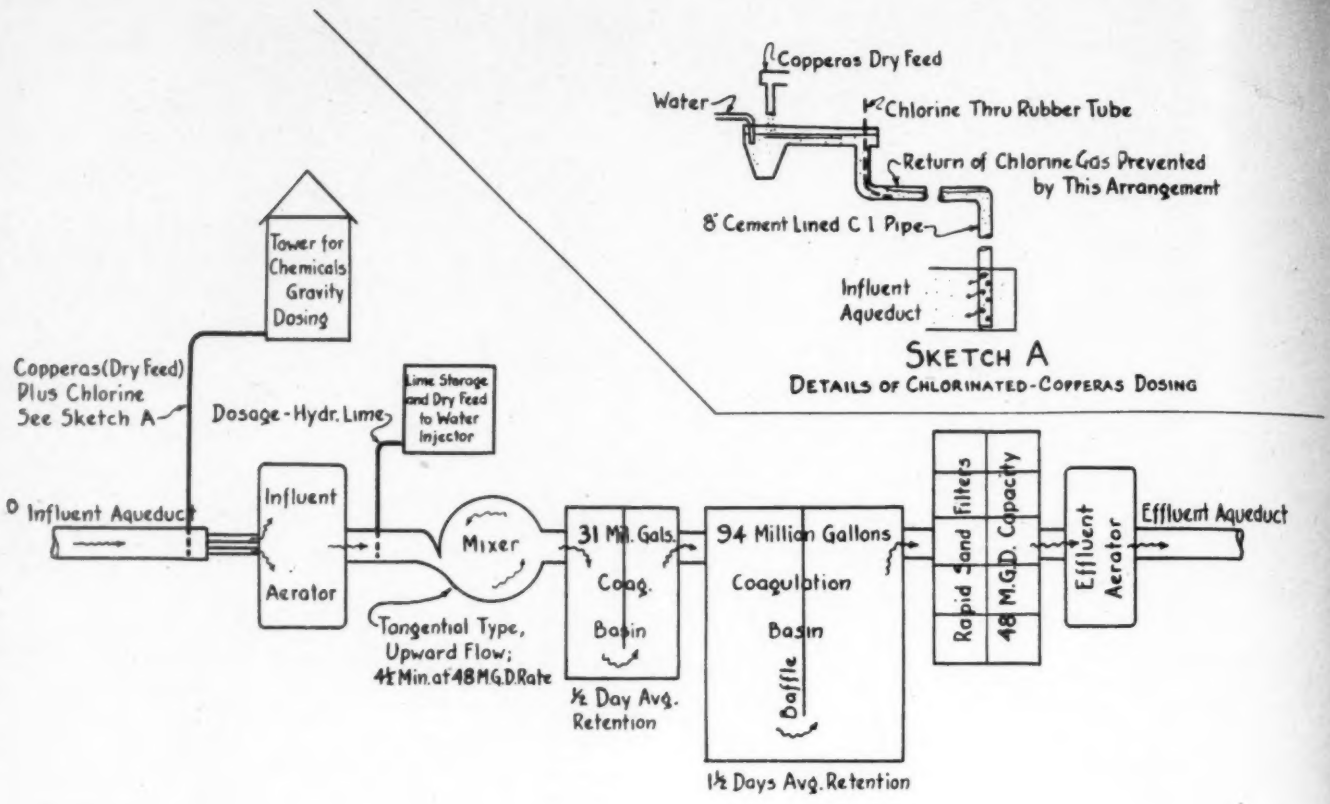

Fig. 1—Schematic Layout of Providence Filtration Plant and Detail Sketch of Continuous Method of Chlorinating Copperas

In the fall of 1929, however, it became apparent from an increasing number of complaints concerning the quality of water at dead-ends, or portions of the distribution system having little circulation, that corrosive tendencies were developing in those portions of the system. A detailed investigation and study of conditions revealed that where circulation was restricted the iron content increased and the water became colored, enough in some cases to be classified as a red-water condition. It was also found that a sediment, containing calcium, aluminum, iron and manganese, had deposited within the covered distribution reservoirs. Later, an investigation of conditions at the impounding reservoir revealed the presence of from 0.05 to 0.75 p.p.m. of manganese in the water held in storage.

Raising the pH value of the plant effluent to around 9.0 during December, 1929, appeared to produce some improvement, although not markedly so at first. Afterward it was found that with the pH value maintained at about 9.3 red-water tendencies were largely eliminated, but a new difficulty was encountered. The rapid deposition of manganese in the system with the pH at this point, more than offset the advantage gained. At a pH of 8.0 to 8.5 precipitation of manganese from an otherwise satisfactory water began and increased with increasing pH value until at pH 9.3 precipitation of manganese was practically complete. Removal of this manganese with the coagulant then in use could not be accomplished because aluminum sulphate (filter alum) will not coagulate soft waters effectively in the range of pH necessary for removal of manganese. Alkali could not be applied prior to filtration because its use resulted in peptization and re-solution of color and floc, which would pass through the filters.

Iron Coagulants Studied

The problem of eliminating manganese and of securing a stable plant effluent was studied intensively during 1930. It was finally decided to abandon temporarily the alum-lime treatment for a new form of treatment: namely, the use of iron sulphate (copperas) and lime. The change was made in August, 1931, and dosages used were as low as 0.15 g.p.g. copperas and 1.15 g.p.g. lime just before the fall reservoir turnover, to as high as 1.5 g.p.g. copperas and 1.2 g.p.g. lime, following the turnover in November, when coagulation was most difficult. The copperas was applied to the raw water which was then immediately aerated.* Hydrated lime was then applied to produce a pH near 10. During passage through the mixer and the sedimentation basins (two day retention) most of the manganese was removed and the remainder was removed by the filters. The chief difficulty encountered was met in handling the copperas which formed lumps in the storage bins.

This probably represents the first successful application of the iron-lime treatment ever made to a soft-colored water on other than an experimental basis. This treatment was continued from August, 1931, to May, 1932, and despite the prophecies of many and conclusions previously drawn by various experimenters, it proved to be a practicable treatment for such a water, producing a filter effluent with pH of 9.6, color of 9, hardness under 40, iron content of 0.10 p.p.m. and with very stable (now corrosive) characteristics.

**See front cover illustration.*

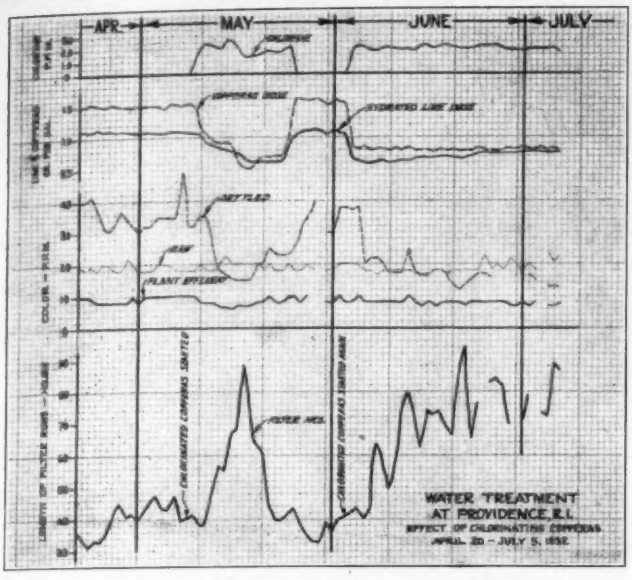

Fig. 2.—Effect of Chlorinating Copperas

Chlorinated Copperas Tried

In May, 1932, continuous chlorination of the copperas solution was tried, producing the so-called "chlorinated-copperas." (See Fig. 1.) In applications of this coagulant elsewhere except in conjunction with softening processes coagulation has usually been produced in slightly acid or neutral solution. At Providence the raw water, treated with chlorinated-copperas, is aerated to release gases and then lime is applied to produce a pH of approximately 9.7—a distinctly alkaline reaction. This is done for two reasons; first, manganese will not be completely removed at pH below 9.2; and second, because subsequent corrosion of the distribution system is not completely prevented at pH below 9.3.

The principal purpose of introducing chlorine into the treatment was to reduce the cost of chemicals. It was found that less copperas was required if the iron be oxidized to the ferric state. Less alkali was also required because a lower pH can be maintained and the total chemical cost was reduced by 20 per cent. In this connection it should be noted that the raw water is drawn from the bottom of the impounding reservoir at all times. This is done for three reasons: first, micro-organisms are avoided; second, the temperature of this deep water is much lower in summer and water delivered at taps in the distribution system is cooler and therefore more palatable; and third, advantage is taken of the content of natural coagulants (dissolved iron and manganese) in this water near the reservoir bottom. Their presence reduces the consumption of purchased coagulant very materially and in the early fall the quantity of iron and other natural coagulants present is such that the need for purchased coagulants is practically eliminated. Oxidation of these natural coagulants (principally ferrous compounds) to the higher form by use of chlorine has a definite value in the treatment.

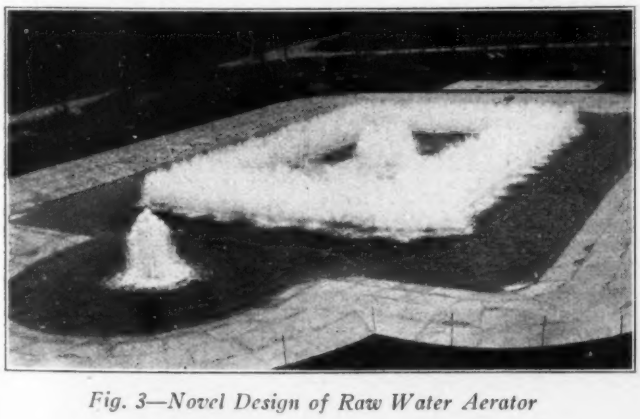

Fig. 3—Novel Design of Raw Water Aerator

Other Benefits Derived

Besides reduction in costs, the change to chlorinated-copperas for coagulation brought several desirable improvements. Use of ferric iron causes much quicker formation of floc, giving quicker precipitation in the sedimentation basins and greater removal of material during the sedimentation period which has resulted in materially longer filter runs than were obtainable when using copperas without chlorine. Ferrous coagulants require a certain period, several minutes preferably, of contact with raw water allowing complete hydrolization of the iron compound before the application of the alkali. Ferric coagulants require a period so short as to be difficult of determination. Practically, a thorough mixing of the ferric coagulant with the water is all that is required before alkali dosing. This factor as well as the quicker floc formation and more complete precipitation mentioned above, make ferric compounds the more

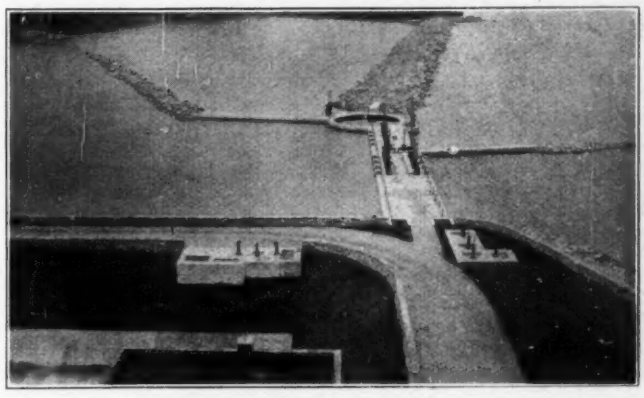

Fig. 4—Circular Mixing Tank in Center Between Two Coagulation Basins of 31 m.g. and 94 m.g. Capacities

adaptable and desirable as well as the most economical coagulants for Providence conditions.

The effluent produced by use of the ferric coagulant is of better quality than that produced when copperas and lime was used. Since less coagulant and less alkali is required the total soap hardness averages about 30 p.p.m. only, the pH is 9.3, color 9, iron 0.05 p.p.m. or less and manganese none; calcium and sulphate are both reduced. The effluent is stable and practically no precipitation takes place in the system. Action on piping is reduced to the point of complete elimination of red-water in the cast iron mains. The total number of complaints received from consumers is now approximately one-tenth the number received before the adoption of the improved iron coagulation.

Ferric Chloride Tried

A ten-day experiment on a plant scale, using ferric chloride as the coagulant, showed that the properties of ferric chloride and chlorinated-copperas, so far as plant operation is concerned, are so nearly the same that they may be used interchangeably on the basis of the actual iron content, the only material change which may be expected in results produced, being the exchange of a certain amount of sulphate for chloride in the effluent. Laboratory experimentation has shown that on this soft, colored water, nearly free from turbidity, the efficiency of the several ferric iron compounds tried, when compared on the basis of their iron content, are all within

10 per cent of being of equal value. This applies to the three compounds which hold promise of availability for water treatment, viz.: chlorinated-copperas, ferric chloride, and ferric sulphate.

These facts are of the utmost interest inasmuch as these three compounds now show real promise of becoming competitively available on the market, in certain localities at least. "Chlorinated-copperas" is probably the cheapest in most localities but preliminary quotations recently received at Providence on solutions of ferric chloride were rather attractive and still more recently a by-product known as "Calcoag," containing 85 per cent anhydrous Ferric Sulphate, granular in form and dry enough to be handled in dry-feed apparatus has appeared on the market. Tests so far indicate this to be a very desirable product which will compete with chlorinated-copperas on the basis of efficacy and costs. With some modifications to provide in the matter of feeding ferric chloride liquor there now appears to be three ferric coagulants available on a competitive basis. The advantages from use of ferric iron coagulants in the treatment of the Providence water are now so well established that there is no question but that their use, in one form or another, will be continued.

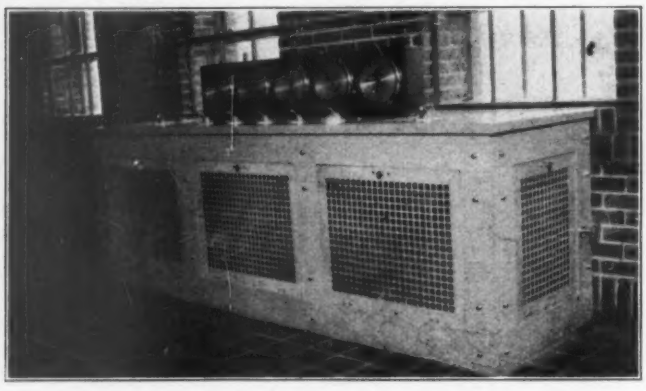

Fig. 5—One of Filter Control Tables

The copperas for producing chlorinated-copperas will average 0.7 grains per gallon and the total chemical cost (including lime and chlorine) for this process of water treatment is around two dollars per million gallons at Providence, with very little difference in cost indicated in case ferric chloride or ferric sulphate should be used instead.

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51st Annual Convention New England Water Works Association

The 51st annual convention of the New England Water Works Association will be held Sept. 27 to Sep. 30 at Springfield, Mass., with headquarters at the Hotel Kimball. The New York Section of the American Water Works Association will meet jointly with the N. E. W. W. A. at Springfield. The program of the convention follows:

TUESDAY, SEPTEMBER 27

Forenoon
10 a. m. Opening, reports, etc.

Afternoon
2 p. m. Description of the Springfield Water Works, E. E. Lockridge, Chief Engineer.
The Cobble Mountain Dam, Harry H. Hatch, Division Engineer.
The West Parish Filtration Plant, Herbert F. Salmond, Chemist.
The Cobble Mountain Power Development, Herbert A. Moody, Hydraulic Engineer, Turner's Falls Power and Electric Company.

Evening
9 p. m. Reception and dance. (Courtesy Manufacturers' Assoc.)

WEDNESDAY, SEPTEMBER 28

SUPERINTENDENTS' DAY

Forenoon: General Discussions upon Meters, Water Main Cleaning and Water Consumption, opened by following papers:
9 a. m. Testing Meters at Hartford, Connecticut, W. A. Gentner, Office Engineer, Water Bureau, Hartford.
10 a. m. Experiences with Water Main Cleaning, Arthur T. Clark, Chief Engineer, Greenwich Water Company, Greenwich, Connecticut.
11 a. m. Water Consumption in American Cities, A. Prescott Folwell, Editor, Public Works, New York City.

Noon
12:30 p. m. Ladies' Luncheon and Bridge. (Courtesy Manufacturers' Asso.)

Afternoon: General Discussion upon Tastes and Odors in Water Supplies, opened by following papers:
2 p. m. Use of Activated Carbon in the Water Works Field, F. E. Stewart, Industrial Sales Company.
3 p. m. Experiences with Chlorine-Ammonia Treatment. To be announced later.
4 p. m. Aeration in Water Treatment, Herman B. Anderson, Vogt Bros. Mfg. Co., Louisville, Ky.

Evening
7 p. m. Dinner Dance. (Courtesy Manufacturers' Asso.)

THURSDAY, SEPTEMBER 29

Excursion to Springfield Water Works

Evening
9 p. m. Smoker. (Ladies invited.) Courtesy Manufacturers' Assoc.

FRIDAY, SEPTEMBER 30

Forenoon
9 a. m. The Recent Drought in New England and its Effect on Water Supplies of Southern New England, Caleb M. Saville, Chief Engineer, Hartford Water Bureau.
10 a. m. Manganese in Impounded Water Supplies, Robert Spurr Weston, Consulting Engineer, Boston.
11 a. m. The Mechanical Conditioning of Treated Waters, R. S. Rankin, The Dorr Company, New York City.

Afternoon
Left free for inspection trips to local points of interest.

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A Pumping Station and Filtration Plant That Operates 20 Hours Per Day Without Steam or Electric Power

A new item in the New York Evening Sun calls attention to the remarkable pumping capacity of the lowly bivalve—Mr. Oyster. It goes on to say that the oyster works at its pumping job 20 hours out of each day and the remaining 4 hours he just loafs, and loafs, and loafs. Another thing of interest is that he has no wife.

Mr. Oyster pumps water into himself and pumps it out again and a steady going oyster, that does not fall asleep on the job, will pump water thus at the rate of two gallons per hour—i. e., 40 gallons per 20 hour working day.

Mr. Oyster also operates an efficient filtration plant within his shell. Every bit of the water pumped in is filtered during its passage through the gills and through its recirculating capacity an oyster will quickly remove the turbidity from water with which it is surrounded. A very few oysters will quickly clear up a barrel of turbid water.

The oyster does not pump for the fun of it. He pumps the 40 gallons of water per day as a life sustaining operation because it is dependent upon the algae and other materials filtered out of the water as its food supply. Few people appreciate the fact that the flavor and plumpness of an oyster is dependent upon the nature and quantity of algae which exist in the water surrounding the oyster beds. Further than being an algae and turbidity remover, the oyster removes bacteria and even metallic salts such as copper, arsenic, etc., from the water. What a purification plant!

OPERATING RESULTS OF FIVE SEWAGE TREATMENT PLANTS IN ILLINOIS

By H. E. HUDSON, Jr.
Sanitary Engineer, Department of Public Works, City of Chicago

A WIDE variety of conditions is found in the sewage treatment works of the Sanitary Districts of Bloomington and Normal, Decatur, Elgin, Springfield, and Urbana-Champaign. Four of the plants have Imhoff tanks and trickling filters, one having pre-aeration units in addition. The fifth is an activated sludge plant. The sewages include domestic, combined, and combined and industrial wastes.

Description of Treatment Works

The Bloomington and Normal plant is located 2½ miles southwest of Bloomington. The two cities have a combined system of sewers which originally terminated in Sugar Creek or its branches. An intercepting sewer now parallels this creek, bringing the flow from the combined sewers to the treatment works. All the sewage treated is pumped. The plant comprises the following: coarse screens, grit chambers, pumping station, Imhoff tanks, sludge drying beds, dosing tanks, trickling filters and secondary settling tank. Figure 1 shows a portion of the plant.

The Elgin plant is situated on the banks of the Fox River. Combined and separate sewers conduct the sewage which has been pumped at several points throughout the city to an interceptor. The sewage finally reaches the works through a pressure main discharging into the grit chamber.

The treatment plant comprises the following units: grit chambers, Imhoff tanks, sludge drying beds, dosing tanks, trickling filters, and secondary settling tanks. The latter are bypassed during the winter months because there is flow enough to provide adequate dilution without use of these units.

The Urbana-Champaign plant is located in the northeast corner of Urbana on the south bank of the Salt Fork Creek, about a mile from the business district. Situated as it is, close to the city and on low ground, there is no necessity for pumping the sewage at any point during its flow to the plant. The works are composed of Imhoff tanks, dosing tanks, trickling filters, and a secondary settling tank.

Urbana and Champaign have a separate system of sewers, the flow from which is brought to the treatment plant through a pair of intercepting sewers. One of the interceptors has a diameter of 30 ins. and the other, a diameter of 18 ins.

A large public park, owned by the Sanitary District, surrounds the treatment works. This park is naturally landscaped and well kept, and the structures are attractive in appearance. The work expended in maintaining appearances is justified by the resulting public approval.

The Decatur plant has pre-aeration units in addition to Imhoff tanks and trickling filters. It is located 2½ miles west of the city and is on low ground on the north bank of the Sangamon River, a site which has been surrounded by a dyke for protection against floods.

This treatment plant has coarse screens, grit chambers, Imhoff tanks, aeration tanks, intermediate settling tanks, dosing tanks, trickling filters, and a secondary settling tank. Pumps are provided to lift the effluent to river level during flood stages.

The flexibility of the plant enables operation of it in different ways. The plant has been operated with the aeration tanks as activated sludge units, and again as pre-aeration units to relieve the load on the sprinkling filters. Hatfield finds that there seems to be little difference in the quality of the effluent resulting from such changes in operation.[6]

The activated sludge plant is at Springfield, about 3½ miles north of the city, on low ground adjoining Spring Creek. The flow from combined sewers is conducted to the treatment works by interceptors. While the plant is not complete as originally planned, it gives

Fig. 1—Screens, Grit Chambers, Pump House, Sludge Pump House and Part of Secondary Settling Tanks at Bloomington, Ill.

at least primary treatment to all the sewage flowing to it and complete treatment to a part of the settled sewage. The works include the following: coarse screens, grit chambers, primary settling tanks, aeration tanks, final settling tanks, digestion tanks, and sludge drying beds.

Character of Sewages

The treatment plant at Urbana-Champaign handles domestic sewage of medium strength, the flow coming entirely from separate sewers. The average flow is 87 gallons per capita per day, except in 1930, during drought, the flow was only 70 gallons per capita per day. The sewage represents a population-equivalent of 29,800 persons, which is less than the actual population of the district served.

Since the sewage is entirely of domestic origin, the grit content is low, but the suspended matter content, which consists largely of particles of organic matter, is average. The sewage is not pumped until after it has received primary treatment, consequently the suspended matter is unaffected by any turbulence other than that which ordinarily occurs in the sewers.

The combined sewage treated at Bloomington is weak because of the few industries contributing wastes. However, the canning factory, the largest industry, adds a

waste at certain times of the year which causes a marked rise in the hydrogen ion concentration. The average daily flow to the plant, 132 gallons per capita, when compared to the average daily per capita water consumption of 80 gallons, indicates that a considerable portion of the sewage comes from ground water infiltration and surface water. This latter observation is borne out by the presence of large quantities of grit and mineral matter in the sewage, and by the fact that large quantities of leaves collect on the screens at certain times.

The sewage treated at Springfield is moderately strong, having a bio-chemical oxygen demand of 166 p.p.m. There are only a few industries in the city that add any considerable quantity of waste to the sewage flow. A large portion of the sewage comes from ground water infiltration and surface water, for large quantities of grit are present in the raw sewage. These factors combine to produce a population-equivalent of 60,800—less than the actual population of the district served.

The treatment works at Elgin, on the other hand, has several industries contributing to the combined flow it receives. As a result, the sewage is fairly strong. It had a population-equivalent of 55,000 persons in 1930, a quantity 57 per cent greater than the actual population.

The sewage arrives at the plant a long time after it is discharged into the sewers, and is, therefore, often stale. Moderate quantities of suspended matter are present in it. This matter consists of very light and small particles as attested by the low settable solids content. This may be attributed to the fact that the sewage at Elgin is all pumped to the plant, and that it is necessary to pump most of it twice, a process which may tend to pulverize suspended particles. The only treatment which the sewage receives before pumping is screening.

At Decatur a starch works contributes industrial wastes to the sewage. However, it applies a reclamation process to the wastes it produces, lowering their strength to such an extent that the sewage is only fairly strong. The population-equivalent of the flow reaching the plant is only 35 per cent greater than the actual population. The starch wastes discharge into the sewers at a higher temperature than that of ordinary sewage, raising the temperature of the plant influent. The sewage contains a normal quantity of suspended matter.

Good efficiencies are secured at all five of the above treatment works, although at Elgin the population-equivalent reduction efficiency dropped in 1930 to 71.2 per cent due to a greatly increased load. The data on the operation efficiencies of the treatment plants, expressed as population-equivalents, are given in Table I.

Screens and Grit Chambers

It is not customary to treat screenings at any of the plants covered in this article, although at Urbana-Champaign, lime is added to them while they are stored awaiting burial. They are usually disposed of as soon as possible after collection. Grit chambers have been provided at the plants treating combined sewage. Most of these have sloping bottoms which keep a uniform velocity throughout and which, at the same time, allow collection of larger quantities of grit between cleanings than the flat-bottomed type of chamber. Some difficulty has been experienced with the operation of the grit chambers because they have been designed to anticipate greater flows than those existing. In consequence, the velocities are low enough to allow the deposition of putrescible matter with the grit.

Imhoff Tanks

As was mentioned above, four of the five plants are equipped with Imhoff tanks for primary treatment, while the fifth, Springfield, employs clarifiers. No undue trouble is experienced in the Imhoff tanks from improper distribution of sludge in the hoppers, as they are all designed with three hoppers per tank, and the flow through them can be reversed. At times, difficulties are encountered in these tanks because of foaming and excessive scum formation.

Temperature plays an important part in the Imhoff tank operation. It is seen that the plant at Decatur treats warm sewage, and the effect may be readily noted in the operation of the primary treatment devices. Good digestion is secured all year around while at some of the plants sludge digestion practically ceases during the winter. This condition has meant much to Decatur, for the Imhoff tanks there have been overloaded at times. In 1927 the sludge digestion capacity of the tanks was 0.97 cu. ft. per capita, based on the population-equivalent of the raw sewage, while the actual present capacity due to reduced industrial wastes, is 3.17 cu. ft. per capita.

Elgin, which has a sewage of a lower temperature than that of the other plants in this study, has experienced trouble from lack of capacity. Each winter the sludge accumulates to or above the slots in the tanks. It has been shown that the rate of gas formation varies directly with the temperature, and that gas production varies with the rate of digestion. Also, the temperature

TABLE I—POPULATION EQUIVALENT DATA

Plant		Bloomington		Decatur			Elgin		Springfield	Urbana-Champaign
Year		1929	1930	1928	1929	1930	1929	1930	1930	1930
Population served		....	38.6	....	....	57.5	....	35.0	71.8	41.8
Population equivalent of raw sewage		29.2	23.4	166.0	111.0	77.8	41.7	54.7	61.0	30.0
Population of plant effluent		3.3	2.4	10.7	9.1	7.7	8.6	16.0	25.7	1.4
Population equivalent reduction by various processes	A	13.1	10.6	34.8	24.9	22.0	11.5	18.1	16.2	14.9
	B	....	....	59.8	23.8	18.4	....	....	(41.2)	....
	C	12.7	10.4	43.0	45.9	28.2	21.5	20.4	....	11.0
	D	....	....	11.2	7.3	2.6	....	....	....	2.7
	E	25.9	21.0	155.0	99.2	71.2	33.0	38.6	(55.8) 35.2	28.6
Percent reduction of population equivalent from raw sewage	A	44.8	45.3	21.0	22.4	28.3	27.6	33.7	26.5	49.3
	B	....	....	36.0	21.4	23.7	....	....	(67.4)	....
	C	43.5	44.4	25.9	41.3	36.3	51.5	37.5	....	36.5
	D	....	....	0.7	6.6	3.3	....	....	....	9.0
	E	88.7	89.7	93.3	89.4	91.5	79.2	71.9	(91.5) 57.7	95.4

NOTE: The above population equivalents and populations are expressed in thousands, and are all based on a figure of 0.17 lb. of bio-chemical oxygen demand per capita per 24 hours.

A—Primary treatment.
B—Aeration and settling.
C—Trickling filters.
D—Secondary settling.
E—Total treatment.
()—Indicate theoretical efficiency under complete treatment.

TABLE II—BIO-CHEMICAL OXYGEN DEMAND OF RAW SEWAGE, 1930

Bloomington	Decatur	Elgin	Springfield	Urbana-Champaign
98	154	283	166	209.5

of digestion, in almost all cases, is practically the same as that of the sewage treated. Therefore, it is obvious that temperature of the sewage has a direct bearing on the digestion and degree of purification obtained by Imhoff treatment. This explains to some extent the lower efficiency of the treatment at Elgin.

Taking the bio-chemical oxygen demand, shown in Table II, as the index of strength, Bloomington treats the weakest sewage.

Settling Tank Efficiencies

The Bloomington plant attains a high efficiency in its 45.3 per cent reduction of population-equivalent by the primary treatment. Urbana-Champaign also reduces the population-equivalent materially, the reduction being 49.3 per cent. Emphasis must be placed on the fact that these two plants, securing the best reduction of population-equivalent, are not loaded to nearly their capacity, while the others are treating more and stronger sewage in proportion to the equipment available. The reduction at Elgin is small by comparison, but the strength of the sewage treated there is far greater. It would appear that the experience at Decatur conflicts with this, since the sewage is weaker and the reduction obtained is low, but the Imhoff tanks there are treating a flow considerably larger than that for which they were designed. The flowing-through chambers in Decatur's primary tanks had a retention period of 1.15 hours under 1930 conditions, while that at Bloomington and Urbana-Champaign was three times as long.

Table III shows the efficiency of the primary treatment in removing solids. Further reason for the low efficiency of the treatment at Elgin may be found in the low gravity of much of the suspended matter which remains in suspension. The long sedimentation periods at Bloomington and Urbana-Champaign account for the high reductions of the suspended matter.

The lower per cent reduction of suspended matter at Elgin closely matches the settling period and it is seen by comparison that the tank efficiency is good.

The 46 per cent reduction which is obtained at Springfield seems low. The primary settling basins there are equipped with continuous sludge removing devices. The agitation caused by these may account for the lesser efficiency than that obtained at Decatur with the same settling time, but at Decatur temperature plays a part. Suspended matter settles more quickly in warm liquor than in cold. The average sewage temperature at Decatur greatly exceeds that at Springfield, consequently, lower settling efficiency may be expected at the latter. This also is in part probably the reason for the smaller reduction at Elgin.

Foaming Troubles

In relation to the foaming in the Imhoff tanks, the reaction of the sewage is of importance. A pH of 6.8-7.2 will induce good operation without foaming. When a plant has once begun operating and the sludge in the digestion chambers is properly seeded, foaming is not apt to take place and a good pH will be maintained. If it is necessary to start the plant without seeding the sludge, violent foaming may occur. Such a situation may arise in the case of a new plant or of an old plant which has been shut down for some time. In the latter case, the sludge in the digestion compartments may have lost its seeding powers. Reaction control, by the addition of lime, is advisable at such times, and, in most cases, tends to lessen the foaming and scum formation. The reaction of the sewage at Bloomington is affected in such a way as to reduce the pH to as low as 6.7 at times. When this condition exists, foaming is almost certain to begin and may become troublesome. Hatfield of Decatur, however, believes that the expense of adding lime to the tanks is not justified by the improvement; that properly designed tanks will still give good results even when foaming. The operators are in disagreement

TABLE III—SETTLING EFFICIENCIES, PRIMARY TREATMENT, 1930

City	Bloomington	Decatur	Elgin	Springfield	Urbana-Champaign
Percent removal of suspended solids	68	57	52	46	56
Period of retention in hours.	3.33	1.15	2.52	1.18	4.63

Fig. 2—Scum on Imhoff Tanks at Decatur. Stop Planks Prevent the Passage of This Material Into the Effluent. The Gas-Collector Bells May Be Seen in the Gas Vents.

over this, and most of them do add lime to their tanks at such times. Fig. 2 shows scum on the flowing through chambers of the Imhoff tanks at Decatur. This scum is prevented from getting into the effluent by scum bonds.

Foaming is not due solely to the reaction of the sewage. Other factors are of importance. Chief among these is the condition of the digestion chambers. In most plants, the digestion chambers fill up during the winter months, and when the temperature rises in the Spring, activity is increased, causing rapid formation of gas. Some times this change in activity seems to lead to the lowering of the pH in the digestion chambers and the acidity produces considerable carbon dioxide gas when reacting with the bicarbonates present.

Trickling Filters

The filters at the various plants are all operating well, although difficulties have been experienced with ponding on the surface of the filters. Chlorination is used to relieve such a situation. Smith at Elgin[10] has found that by chlorinating the beds whenever they show signs of clogging he can entirely prevent the ponding of the filters. He adds chlorine gas by means of a regular chlorinating machine. At Bloomington good results have been obtained from use of chlorinated lime thrown into the dosing tanks. The chlorination is almost invariably followed by a heavy sloughing off of the organic matter surrounding the filter stone.

Buswell[1] and Rudolfs[3] have shown that almost all the bio-chemical oxygen demand reduction takes place in the upper six feet of filters. Since most filters are six

TABLE IV—LOADINGS AND EFFICIENCIES OF TRICKLING FILTERS

City		Area of Filters, Acres	Depth of Filters, Feet	Flow MGD per Acre	Thous. Pounds BOD Load per Acre Daily	Thous. Pounds BOD Reduction per Acre Daily	P. E.* Load per Acre Daily in Thous.	P. E. Reduction per Acre Daily in Thous.	Per Cent Reduction of BOD
Bloomington and Normal	1929	....	....	3.35	1.73	1.37	10.1	8.0	79.1
	1930	....	....	*3.08*	*1.38*	*1.13*	*8.1*	*6.6*	*81.5*
Average		1.58	8.0	3.21	1.56	1.25	9.1	7.3	79.8
Decatur	1928	....	....	3.42	3.96	2.75	23.4	16.1	69.2
	1929	....	....	3.79	3.48	2.58	20.5	15.1	73.5
	1930	....	....	*3.42*	*2.14*	*1.58*	*12.6*	*9.2*	*73.3*
Average		3.05	6.3	3.54	3.19	2.30	18.8	13.5	72.0
Elgin	1929	....	....	2.79	3.42	2.44	20.1	14.3	71.4
	1930	....	....	*2.63*	*4.14*	*2.32*	*23.7*	*13.6*	*56.0*
Average		1.50	8.0	2.71	3.78	2.38	21.9	13.9	63.7
Urbana-Champaign	1930	1.60	10.0	1.83	1.60	1.16	9.4	6.8	72.5

*P. E. = population equivalent.

feet or more in depth, it does not seem proper to express B.O.D. loads in terms of units of volume.

The loads on trickling filters play important parts in producing good effluents as shown in Tables IV and V. For ordinary ranges of B.O.D. loads, the variation of efficiency in removing bio-chemical oxygen demand is slight: that is, the per cent reduction of oxygen demand is generally between 60 per cent and 80 per cent. Fig. 3 shows the relation of load to removal. Rudolfs[3] shows a parallel relation for the B.O.D. reduction at Plainfield, N. J.

The crushed limestone used in the four Illinois plants passed a 2 in. ring and was retained on a 1 in. ring. The crushed stone used at Plainfield, N. J., was larger, since it was graded to pass a 2½ in. ring and be retained on a 1 in. ring. This difference in size, giving a larger surface area per unit volume for the stone used in Illinois, offers explanation for the difference between the curves.

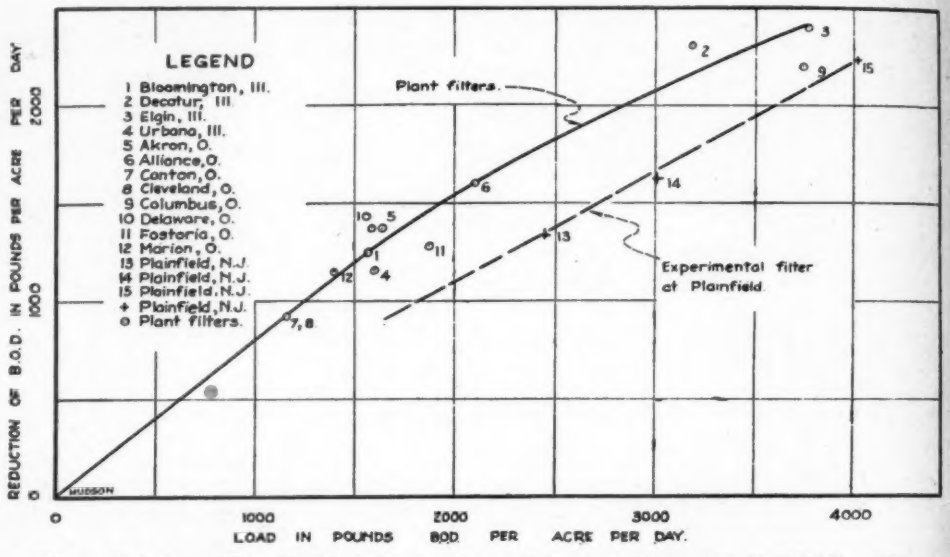

Fig. 3—Relation of Bio-Chemical Oxygen Demand Loads to Reductions in Trickling Filters.

Study of this curve shows that the results of operation of the trickling filters here discussed are not out of line. Decatur, treating a warm sewage and employing preaeration, effects a treatment better than normal, while Elgin produces a reduction which is not as good as the average. This is to be expected because of the lower temperature of the sewage at Elgin and the high suspended matter content of the applied sewage.

At Bloomington and at Urbana, good efficiency may be expected and obtains. These two plants treat weak influents and, since their filter areas are ample, the loads are light.

The insect nuisance, caused by the Psychoda fly, is combated by flooding the filters when possible. It is a theory that the Achorutes feed upon the larvae of the Psychoda, but Peterson[4] has shown that they will molest the larvae only if there is no other food supply. It is possible that the Achorutes, living on the filters at Illinois treatment plants, reduce the Psychodas somewhat, but the insects are still very numerous.

TABLE V—TRICKLING FILTER EFFICIENCIES AND LOADINGS[2], [3]

City	Pounds BOD Load per Acre	Pounds BOD Reduction per Acre	Per Cent Reduction of BOD
Ohio Cities[2]			
Akron	1,630	1,370	84
Alliance	2,100	1,600	76
Canton	1,162	903	78
Cleveland	1,170	910	77
Columbus	3,753	2,203	63
Delaware	1,592	1,384	87
Fostoria	1,894	1,282	68
Marion	1,390	1,150	83
Plainfield, N. J.[3]			
A	2,440	1,350	55.5
B	3,010	1,630	54.5
C	4,050	2,240	55.5

These data are taken from Hatch[2] and Rudolfs[3] and converted to loads per unit area of the filters.

Aeration

No comparison of the aeration treatments given at Springfield and Decatur can be made because of the difference in conditions. Table VI gives the data on the treatments.

No endeavor is made to produce a completely stable effluent by aeration at Decatur because the liquor from this treatment flows to the trickling filters and oxidation is completed there. The aeration process is used to reduce the load on the trickling filters and the bio-chemical oxygen demand reduction effected is between 30 and 35 per cent. This is probably not a fair measure, however, for it is thought that the pre-aeration treatment

TABLE VI—DATA ON AERATION TREATMENTS

City	Decatur			Springfield
Year	1928	1929	1930	1930
Time of aeration—hours	3.14	2.40	2.46	6.25
BOD of influent	256	152	111	122
BOD reduction	117	42	36	112
Per cent BOD reduction	45.7	27.6	32.4	91.8
Cubic feet of air per gallon sewage	.383	.615	.384	1.30
Sewage flow through aerators MGD	7.95	10.40	10.22	2.7

attacks the more easily oxidizable matter leaving the more difficult components for the filters to cope with.[5]

Dr. Hatfield gives a very complete discussion of the operation of the Decatur pre-aeration plant in which he shows that the process does equally well in any of three ways of operation: either as straight aeration, as aeration with sludge return, or as aeration with return of re-aerated sludge.[6] It is indicated from the operation of this plant that better bio-chemical oxygen demand reduction will be obtained in a full size aeration plant if the return sludge be reaerated. This method also promises the most freedom from odors. The sludge produced by reaeration is good, but must be carefully watched for signs of bulking. The volume of sludge returned has varied from 5 to 20 per cent of the sewage flow.

Since aeration at Springfield comprises the whole of the secondary treatment, a good reduction of bio-chemical oxygen demand may be expected. Computed on the basis of the quantity of sewage aerated, the reduction is 92 per cent. However, all of the plant influent does not receive aeration. The secondary capacity is not sufficient for complete treatment, and about 60 per cent of the primary effluent is by-passed. Consequently the population-equivalent reduction is about 15,000.

The blowers used in supplying air are synchronous, and having been installed to meet future needs, cannot be controlled as desired at present. The 1.30 cu. ft. of air per gallon of sewage will probably be reduced to 0.8 cu. ft. when the remainder of the aeration units are built.

C. C. Larson, Chemist at Springfield, considers a solids content of about 4,000 p.p.m. desirable in the aerators.[7] He regulates the quantity of return sludge in a manner to maintain his relationship.

Gas Collection

The gas collectors used at Decatur are of the Imhoff type with the grids removed. These function excellently, providing enough gas to heat the buildings and the air entering the blowers. A considerable surplus is burned to prevent odors. There is a flow of gas of about 48,000 cu. ft. per day.

Downes floating steel covers collect the gas from the sludge digestion tanks at Springfield. It is necessary to weight these covers in order to provide pressure enough to use the gas for heating the buildings and the digestion tanks. Gas production averages about 24,000 cu. ft. daily.

Secondary Settling Tanks

At Elgin, it is not deemed necessary to operate the complete secondary treatment all year. During the winter months there is sufficient dilution to make it safe to by-pass the secondary settling tanks. Since they are small and remove only a fraction of the load, they are of little benefit.

The practice at Bloomington is to run the clarifier for only a short time at intervals, generally just before the humus begins to gas. It is thought that the clarifier mechanism causes a circular current in the tank which disturbs the settled sludge and prevents proper sedimentation.

The Imhoff tanks at Bloomington appear to suffer from the transfer to them of humus sludge from the final clarifier. There is but little knowledge concerning the effect of the addition of humus sludge to the sludge in the Imhoff tanks. The same difficulty was had at Urbana and at other plants, outside this group, notably Akron.[8]

It is a general practice to discharge the sludge collected from the secondary tanks into the Imhoff influent,

TABLE VII—CHEMICAL ANALYSIS AND DAILY PUMPAGE AVERAGE

	YEAR	BLOOMINGTON & NORMAL			DECATUR					ELGIN				SPRINGFIELD				URBANA-CHAMPAIGN			
		RAW SEWAGE	IMHOFF EFFLUENT	FINAL EFFLUENT	RAW SEWAGE	IMHOFF EFFLUENT	AERATION LIQUOR	FILTER INFLUENT	FILTER EFFLUENT	IMHOFF INFLUENT	IMHOFF EFFLUENT	FILTER EFFLUENT	FINAL EFFLUENT	RAW SEWAGE	PRIMARY EFFLUENT	SECONDARY EFFLUENT	FINAL EFFLUENT	RAW SEWAGE	IMHOFF EFFLUENT	FILTER EFFLUENT	FINAL EFFLUENT
BIO-	1928	142.0	83.0	13.4	324	256	2.52	139	43											27.0	
CHEMICAL	1929	112.4	61.7	12.8	196	152	155	110	29	203	147	42							206.6	29.7	22.0
OXYGEN	1930	91.0	53.6	9.9	154	111	114	175	20	283	189	83		166	122	10	70	209.5	105.3	28.6	9.8
DEMAND	AVG.	117.5	32.8	12.0	225	175	174	141	31	243	168	62		166	122	10	70	209.5	155.9	28.4	15.9
	1928	300	87	32	202	88	386	116	76	173	64	29	29					202		34	
SUSPENDED SOLIDS	1929	255	76	17	183	98	257	90	51	175	85	39	30					213	93	32	30
	1930	186	59	20	200	87	210	85	55	267	124	56		186	96	24	70	200	87	49	27
	AVE.	247	74		195	91				205	91							205	90		
	1928	8.7	9.3	1.0	13	16	15	15	7									8.0		1.9	
AMMONIA NITROGEN	1929	7.2	9.2	1.4	8	10	9	9	4	6.8	8.6	1.6						17.5		5.2	
	1930	11.1	13.5	1.9	8	10	8	7	5	10.9	12.3	7.3						20.3		3.9	
	1928	0.86	0.62	7.8					4.7	4.7										6.7	
NITRITE & NITRATE NITROGEN	1929			8.5					2.3	1.7	2.7	7.8								16.5	
	1930			8.3					3.8	2.2	2.6	5.6								13.7	
	1928	70.0	49.5	25.0	154	121	165	85	48		60	14	10					94.7	57.1		
OXYGEN	1929	54.7	38.8	16.1	81	66	86	56	30		54	14						101.8	63.5		
CONSUMED	1930	57.4	40.1	21.1	102	78	93	65	38												
	AVG	60.7			112													98.2			
SETTLEABLE	1928				40	11	68.0	9.1	2.2	20								4.2	0.1		
SOLIDS	1929				38	13	10.0	3.0	1.6	3.2	1.2							5.8	1.2		
CC/LITER	1930				2.8	0.5	15.4	3.9	1.4	5.3	1.2							7.2	1.2		
AVERAGE	1928				10.43					3.40								3.63			
DAILY	1929	5.29			11.54					4.18								3.76			
PUMPAGE	1930	4.87			10.45					3.94				7.5				2.92			
IN MG.	AVG	5.08			10.81					3.84				7.5		2.7		3.44			

HUDSON

although Dr. Hatfield has found it best to pump the humus sludge back to the aerators and recirculate it with the return sludge.[9] The micro-organisms in the humus are desirable in the oxidation treatments but they are hard to maintain in the pre-aeration system.

At some plants, humus has been pumped directly into the digestion compartments of the Imhoff tanks, but this seemed to disturb the digestion process.

Chemical Analysis

There is considerable variety in the manner in which analyses are made and interpreted. At some plants it is customary to run analyses daily, while at others, they are run twice a week, and at still other plants, the determinations are not on any regular schedule. No two of the plants make the same tests. The importance of two of the determinations is generally recognized, viz.—those for bio-chemical oxygen demand and for suspended solids. A test for the settleable solids content is usually run and the majority of the records also include determination of the ammonia nitrogen content. Table VII gives some of the chemical results of treatment.

Bio-chemical oxygen demand is one of the best known and most valuable tests for use in the operation of sewage treatment works. The computations for population-equivalent are based upon it and it forms a convenient yardstick for the comparison of the strength of the sewage. In order to run this determination properly, a careful and exact laboratory procedure is needed, for it is easy to make errors which will materially influence the result. The other analyses do not require the degree of care and accuracy required in this test.

Some operators are of the opinion that the dissolved oxygen content gives an indication of the quality of the effluent and that a high content indicates an effluent which is almost entirely purified. In some cases this may be true, but if a sample of the sewage after leaving the treatment were to be incubated for a while, it would probably be found that the dissolved oxygen content had been reduced to nothing. In other words, while the dissolved oxygen content may be an indication of what kind of treatment the sewage has undergone, it does not necessarily indicate the degree of purification of the sewage.

There is much discussion as to the value of the analysis for oxygen consumed. Some claim that the test has no practical value, while others state that it aids them in conducting other determinations. The test is affected by certain influences in such a manner that its results may be considerably in error. The bio-chemical oxygen demand may vary widely and in the analysis by the dilution method, there is often opportunity for the demand to exceed the oxygen available in the mixture. Dr. Hatfield and others have shown that, for any given conditions, as those for any particular sewage, there is usually an approximate relation between the BOD and oxygen consumed; the BOD of the raw sewage at Decatur is roughly 2 or 2½ times the oxygen consumed. Proper use of this test may therefore be made in approximating the dilution to use for sewage analyses.

Summary

The character of the raw sewage has a strong influence on the efficiency of the treatment. Important among the factors contributing to this influence are temperature, strength of sewage, and type of suspended matter.

The temperature of the sewage has a pronounced effect on the efficiency of the sewage treatment, higher temperatures inducing higher efficiencies. The application of this principal is becoming more general since engineers are using heat to aid sludge digestion. It may sometime be possible to heat the whole sewage with digestion gas, increasing both the physical and biological activities.

There is a positive, although approximate, relation between the loads on trickling filters and the efficiencies and reductions obtained in the filters. This may be a straight line relation, but the data above presented point toward a curve.

It is indicated from operation results of the Decatur preaeration plant[6] that better results will be obtained in true activated-sludge operation by reaeration of return sludge.

A lack of standardization exists as to which tests to run. Better comparisons of results could be made if a given set of analyses were run at all plants of the same type. These would benefit the operation as well as the gathering of information for other purposes.

Acknowledgment

The author is deeply grateful to the superintendants of the treatment works, Mr. H. E. Wilson of Bloomington, Dr. W. D. Hatfield of Decatur, Mr. E. E. Smith of Elgin, Mr. G. H. Radebaugh of Urbana, and to Mr. C. C. Larson, chemist at Springfield, for their assistance in the collection of these data.

The author is also indebted to Professor H. E. Babbitt of the University of Illinois for his guidance in the assembling of the data.

In a forthcoming issue Mr. Hudson will present "Operating Costs at Illinois Sewage Treatment Plants" —Editor.

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Fall Meeting of the New York Section A. W. W. A.

The officers of the New York Section of the American Water Works Association have accepted an invitation from the New England Water Works Association to meet jointly with the latter at Springfield, Mass., September 27th-30th. This joint meeting will embrace the regular Annual Convention of the N. E. W. W. A., and will take the place of the regular Fall Meeting of the New York State Section of the A. W. W. A., which will hold one informal session during the joint convention at Springfield. Hotel Kimball will be headquarters and the accessibility of Springfield should result in a large attendance by New York water works men.

This announcement comes from R. K. Blanchard, Secretary of the New York Section of the A. W. W. A.

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor
Physical Chemist, Bureau of Engineering, Chicago, Ill.

SPECIFICATIONS FOR POWDERED ACTIVATED CARBON

PART 1.

THE extensive use of powdered activated carbon in the water works field has made it necessary to draw specifications which will insure to the purchaser the service expected of powdered carbons. One may tell with the eye when many products deviate materially from some specified quality, but in the case of carbons these may vary all the way from ordinary charcoal with very little adsorption capacity to the highly active carbons and yet look exactly alike and have the same carbon content. The highly active materials may be over one hundred times as adsorptive as some of the ordinary chars. The quality which is desired in carbon is the power to remove objectionable taste and odor producing substances from water by a process known as adsorption and the subsequent removal from the water along with the carbon.

In buying activated carbon, it might be said that one is purchasing taste and odor removal. The material which gives the greatest reduction of these compounds at the lowest cost is to be preferred, unless there is some special condition in which other qualities should be considered and given some weight. Where the carbon is added to the water just before it goes into a settling basin the rate at which the material settles out in the water may have some influence upon its effectiveness. If the carbon is added just before the water goes to the filters consideration must be given to the rate at which it clogs the filters. Usually the carbons can be compared on the basis of their adsorption capacity, though it may be found that other factors such as the apparent density should be given consideration.

Tests for Activated Carbon

The test used to determine the adsorption capacity of carbons should be one that gives a true indication of the effectiveness of the material in removing objectionable tastes and odors from water. If a single compound was responsible for taste and odor in water, and it was a compound which could be determined quantitatively, this compound should be used for testing the carbon. It is apparent that the taste and odor producing substances which give trouble in our public supplies are many. It would not be surprising if the number was greatly in excess of fifty and the chemical characteristics of perhaps less than five of these compounds are known.

Most Taste and Odor Producing Compounds Are Not Known and Cannot Be Used for Testing Carbon.—For the vast majority of water supplies the chemist cannot identify one single compound responsible for tastes and odors. It may be said that the water has an algae taste, but that is about as indefinite as saying that the water contains chemicals in solution. At least we do not know what the compound is which produces the taste defined as "algae taste," nor how to determine it quantitatively. Not alone is this true for algae taste but it applies to nearly all the tastes which are referred to as aromatic, decaying vegetation, decomposition, earthy, fishy, grassy, marshy, mouldy, oily, pig pen, sewage, swampy, tarry, woody, etc. It would be impossible to use any of these tastes as a means of accurately evaluating activated carbons, even though the chief use of carbon may be for their removal from water. It might take 0.01 p.p.m. of some compound to produce a distinct swampy taste in water, whereas for some other compound it may require 1.0 p.p.m. to produce the same intensity of swampy taste. The carbon may adsorb the two compounds in almost equal proportion, consequently if one was trying to test carbon with the compound that required 0.01 p.p.m. to produce a taste and another person was using the compound which required 1.0 p.p.m., it is evident that the results would not compare very well. With the exception of phenol, chlorine, and hydrogen sulfide, there is scarcely a taste-producing substance likely to be present in a public water supply which may be determined quantitatively.

Tests for Activated Carbon.—One of the first attempts to evaluate the adsorption of active carbon was by the Chemical Warfare Service of the United States Army in their specifications for gas mask carbon (1). Air containing a known concentration of some toxic vapor such as chloropicrin was passed at a constant rate into a tube of fixed diameter containing a 10-centimeter layer of carbon of a definite fineness. The capacity of the carbon was expressed by the number of minutes required for a detectable trace of vapor to appear in the exit air. The weight of the gas adsorbed was determined directly. This test has many objections, for the amount of chloropicrin adsorbed is affected by the concentration of the vapor, the rate of flow of air, the fineness of the carbon, and other factors. It seems evident that such a test would not be suitable for testing carbon which is to be used in water.

The molasses test is used quite extensively for testing the decolorizing properties of carbon. The molasses solution is usually diluted to procure some definite color and the efficiency of the carbon is determined by the amount of carbon required to effect a definite color reduction. Color adsorption apparently follows the Freundlich adsorption equation and there is the probability that some idea of the adsorption capacity of carbons for taste and odor producing compounds may be determined by

the molasses test though it is doubtful if it is very accurate. At the present time there is no specific data to show the relation between color adsorption by activated carbons and their effectiveness in removing taste and odor producing compounds from water. It would seem unwise to use the molasses test for evaluating water purification carbons.

Barker (2) exposed the carbon to a saturated vapor of carbon tetrachloride at 24 degrees C. and weighed the amount adsorbed. No investigation has been made as to the practicability of using carbon tetrachloride, but it does not seem probable that it has advantages over phenol.

Chlorine is not suitable for testing activated carbon, for raw lignite and ordinary wood charcoal have the power of converting chlorine to hydrochloric acid in the presence of water. Iodine has been used for testing carbon, but it is not believed to be suitable for evaluation of water purification carbons. It does not seem probable that bromine could be used. Aniline might be suitable, but the only method of testing of which the writer is familiar requires a much higher concentration to be detected than is required of phenol. When there is a fairly high concentration of phenol in solution it can be determined just as easily as aniline.

The Phenol Adsorption Test

Of the taste-producing compounds which might be present in some water supplies, phenol is the only compound which may be determined accurately when present in very small quantities. In addition to this it is a compound readily adsorbed by activated carbon. The phenol test is recommended at the present time as being the most reliable test for activated carbon. The method of determining small quantities of phenol requires considerable labor, but the test is not difficult. Small water purification plants may not have a chemist capable of making the test, yet such plants could arrange to have the tests made by some commercial laboratory at a reasonable cost.

The following specifications are offered, not with the feeling that they are perfect, but with the belief that they will give reasonable protection to those who purchase their carbon under such specifications. As soon as information is available which shows that changes are desirable it is easy to incorporate the change in future specifications. At present it is essential to have something to bring order out of chaos.

Specifications for Powdered Activated Carbon

Definition

Activated carbon is a carbonized material in which part of the surface atoms of the carbon will adsorb certain other compounds. It is formed when carbonaceous substances are first carbonized in closed vessels and then given a special heat treatment so as to leave the surface atoms in a condition in which they will adsorb such substances as tend to unite with carbon. Ordinary charcoal has very little adsorption capacity and is not classified with the active carbons.

Shipping, Weighing and Sampling

Shipping.—The material shall be shipped in paper lined bags, cardboard cartons, paper lined barrels, or in tightly closed metal containers. The container shall be such that it can be handled in shipment without loss or excessive dusting.

Weighing.—As the carbon may adsorb moisture in shipment, it will be weighed upon receipt of the material at approximately the same time as it is sampled. Enough of the empty containers will be weighed to get an average of their weight, and the estimated weight of the containers will be deducted from the total weight.

Sampling.—At least 10 per cent of the barrels, bags or other containers will be sampled for testing immediately upon receipt of the material. Approximately the same size sample will be withdrawn from each container. These samples will then be placed in a larger container, thoroughly mixed and two portions of approximately one-quarter pound each of the mixed sample will be withdrawn and put in tightly closed containers to be used for testing. One of these samples will be returned to the manufacturer, if requested, and the other will be used to determine the adsorption capacity of the material. Precaution will be taken to prevent the material from coming in contact with the air more than is necessary until after it has been weighed for adding to the solutions containing phenol. The sample will be used as collected and will not be dried or treated in any manner before being tested. It may be found more convenient to weigh out a fairly large amount of the material and make into a suspension for applying measured portions of the suspension to the samples of water, instead of weighing the small amounts required for each portion of solution.

Requirements

Fineness.—The carbon is to be applied into the water in the powdered form and it must be of such fineness that it will not settle rapidly. At least 75 per cent of the material shall pass a 200-mesh sieve and at least 95 per cent shall pass a 100-mesh sieve.

Screen Test.—The wet screen test shall be used for determining the percentage of carbon retained on the screens. Weigh accurately about 10 grams of the carbon and place in a vessel of known weight such as a platinum dish. Place in a drying oven at 140° C. for 2 hours, cool in a desiccator, then again weigh the sample accurately and as rapidly as possible to prevent moisture adsorption. This determines the loss by drying, which has no special significance except to give a record of the moisture content of the carbon. Place the weighed dry sample into a beaker and add about 600 to 700 cc. of water, wet the carbon thoroughly, stack the screens with the 100-mesh screen on top, then wet the screens thoroughly. Slowly pour the mixture of carbon and water onto the screen, taking care not to plug the screens. It is well to mix the carbon and water once or twice while pouring. Wash all the carbon from the beaker. After all of the carbon has been washed onto the screens, wash with a small stream of water until it is believed that no carbon continues to pass through the screens. Separate the screens and place the 100-mesh screen over a large white porcelain dish and collect in this dish the water passing the screen. If additional carbon continues to pass, it can readily be seen on the white surface. Wash the carbon passing the 100-mesh sieve, which is collected in the porcelain dish onto the 200-mesh sieve. Wash the carbon on the 200-mesh sieve with a small stream of water in the same manner until practically no carbon is observed in the water collected in a porcelain dish.

By means of a stream of water from a small hose, transfer the carbon remaining on each screen into separate beakers. Transfer the carbon in each beaker into separately tared Gooch crucible fitted with an asbestos mat. Dry the crucibles and carbon in an oven at 140° C. Cool them in a desiccator and weigh them. The weighing must be done rapidly to prevent as much moisture absorption as possible. The net weight of carbon in each Gooch crucible times 100, divided by the dry weight of the original sample, gives the per cent of carbon of each size. The amount of carbon retained on the 200-mesh

sieve plus the amount retained on the 100-mesh sieve gives the total that would have been retained on the 200-mesh sieve.

Suggested Phenol Adsorption Requirement.—It has been found that the phenol adsorption capacity gives a very good indication of the suitability of the material for removing taste and odor producing compounds.

Thirty-five parts per million of the carbon should reduce the phenol in a solution which contains 0.10 parts per million of phenol to 0.01 part per million when stirred for two hours. A material in which the 35 parts per million added to the water just produces this reduction is regarded as having the specified adsorption capacity. If a lesser amount of the carbon is required, it is above the specified strength and payment will be made in accordance with its higher adsorption capacity. The price per pound or ton will be multiplied by 35 and this value will then be divided by the parts per million of carbon actually required to reduce the phenol from 0.10 part per million to 0.01 part per million. To illustrate: If the price is 5 cents per pound on the basis of the material being of the specified strength, and 30 parts per million gives the desired phenol reduction, the 5 cents will be multiplied by 35 and then divided by 30, which will give 5.83 cents per pound, the price to be paid for the carbon. It is desired to have material of high adsorption capacity and it will be penalized for falling below the requirement in a greater ratio than its adsorption capacity. The penalty which will be deducted from the price of the material falling below strength will be at the rate of 3 per cent for each part per million required above the 35 parts. To illustrate: If it requires 50 parts per million of the material to produce the specified phenol reduction, this is 15 parts more than the requirement. 15 times 3 gives 45 per cent. If the bid price is 5 cents per pound, the 45 per cent penalty will make a price of 2.75 cents per pound to be paid for the carbon.

Phenol Adsorption Test.—Add 0.10 part per million of pure phenol to each of at least 6 samples of water. The water should be clear filtered water or distilled water either of which is free from phenol and chlorine. A two-liter sample is a convenient amount to use, but a larger or smaller sample may be used if desired. No carbon is added to the first sample, though it should be stirred and carried through the same procedure as those containing the carbon. To the other samples add varying amounts of the carbon, beginning with 10 parts per million of carbon and increasing 10 parts per million for each successive sample until 50 parts per million of carbon is added to the last sample. Immediately after adding the carbon, start stirring the solutions and continue for two hours. The agitation produced by the stirrer should be sufficient to keep the material fairly uniformly distributed throughout the water, but it should not be violent.

After two hours stirring, a portion of each solution required for testing is filtered through paper to remove the carbon, and this portion is then tested for residual phenol, either by the Baylis-Gullans modification of the Gibbs method which is described in another paragraph or by some other accurate phenol determination. If 50 parts per million of the carbon does not reduce the phenol below 0.01 part per million, larger amounts of the carbon should be used. The temperature of the water for making the tests should be held between 20° and 25° Centigrade.

Plot the points on cross section paper with one ordinate in parts per million of carbon and the other ordinate in parts per million of phenol remaining in solution. A curve is then drawn so that it will pass approximately

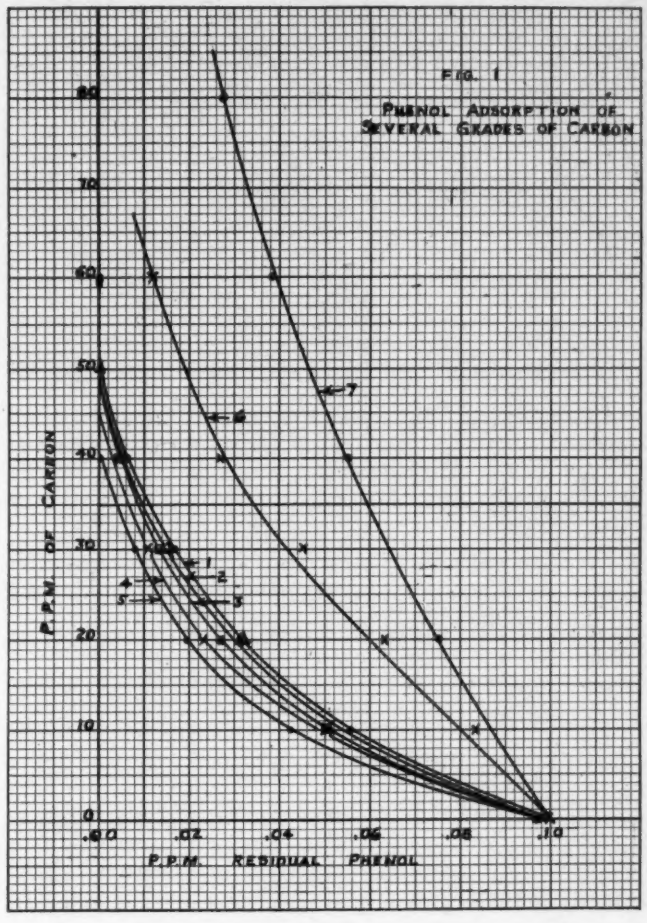

Fig. 1.—Phenol Adsorption of Several Grades of Carbon

through the points. It should be a regular curve and not broken at each point. The parts per million of carbon are then obtained from the point where the curve crosses the line of 0.01 part per million of phenol remaining in solution. (Note.—Where a large amount of carbon is received in one shipment it might be well to make more than one test and state that the curve shall be the average of two or three sets of tests which do not vary more than 5 per cent from the lowest to the highest. Curves for several commercial carbons and special samples are shown in Figure 1 to illustrate the method of determining the points where the curves cross the line of 0.01 p.p.m. of phenol. The names of the carbons are not given, but the group of curves from Nos. 1 to 5 include Nuchar, Hydrodarco, Cliffchar, and Norit. The writer did not have a sample of Carbex so as to show a curve for this material. It is not intended to show all the carbons on the market, but to show how the carbon curve is plotted. Some of the tests were made on samples taken from bags of the material which had been on hand for some time, and others were from special samples furnished by the manufacturer which no doubt were carefully prepared. The curves are given to illustrate the method of determining the amount required to give the specified phenol reduction. The commercial products of the several materials which show high adsorption probably will run very close together. With the exception of Carbon No. 1, all in the group from 1 to 5 pass the specified strength and would receive a bonus if paid for according to the specifications.)

It is evident that each city will have to make certain additions to the specifications, such as the amount of

material to be included in each shipment, the laboratory which is to test the material, etc.

Note: Lack of space prevents printing of the modified procedure used in the author's laboratory to determine the residual phenol in carbon treated samples. It will appear in full in WATER WORKS AND SEWERAGE for October.—*Editor.*

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Book Review

WATER PURIFICATION CONTROL, by Edward S. Hopkins, Principal Sanitary Chemist, Bureau of Water Supply, Baltimore, Md., Williams & Wilkins Co., Baltimore, 1932, 8 vo., 131 pp., 35 ills. Price $1.75.

Reviewed by Wellington Donaldson

Of Fuller & McClintock, Consulting Engineers, 170 Broadway, New York City.

This small volume by the well known chemist-operator of the Baltimore Filtration Plants assembles in a concise and very interesting manner not only the experience gained in training personnel for the Baltimore plants but also the experience reported from other localities as well. The outstanding feature of Mr. Hopkins book is the thoroughly up-to-date treatment of the subject which is handled from the viewpoint of one actually in charge of operation. The reviewer agrees with the foreword by Abel Wolman congratulating the author on making his experience available to others and in recommending that the book find a place on each operator's desk.

The title is somewhat more inclusive than the contents justify, since no reference is made in the book to the operation of slow sand filters or water softening plants. Taking, however, the typical water purification plant comprising coagulation, filtration and chlorination the author has brought together in an able and scholarly manner material of interest to the plant operator, bearing directly upon the practical problems of plant operation.

It is inevitable, of course, that in a frank statement of views some opinions must be advanced which run counter to prevailing views elsewhere on controversial subjects such as the relative merits of mixing facilities, allowable turbidity in the applied water, rates of washing, size of filter sand and relative merits of dry and solution feeds, etc. The important point is that in such discussion sound advice has been given which may be interpreted in the light of local conditions and proper adjustments made.

The various processes employed in water purification are treated in logical sequence in seven chapters dealing with Coagulation, Sedimentation, Filtration, Disinfection, Taste and Odors, Corrective Treatment and Plant Control data. Well chosen illustrations amplify the text, and tables have been inserted where desirable. The excellent bibliographies at the end of each of the seven chapters have been compiled with considerable judgment and comprise a very valuable index to the widely spread literature. And unfortunate omission is the absence of reference to the fundamental work on coagulation by Theriault and Clark of the U. S. Public Health Service, as these results have been widely commented upon.

One notable feature of the book is the presentation of subject matter not found or at least not sufficiently stressed elsewhere. An instance is the explicit directions for determining the proper coagulation dose by means of the laboratory stirrer. The value of the laboratory stirrer for this kind of work is just beginning to be generally recognized. Also, pains have been taken to point out the function of the mixing chamber as a floc forming step, separate and distinct from the succeeding one of subsidence. The separation of these two steps constitute a notable advance in the art within recent years.

Control of the duration and intensity of filter wash by adopting a turbidity limit for the wash water is good advice for many plants accustomed to empirical wash methods.

Discussions on manganese removal are especially appropriate at this time and most operators will welcome the discussion on taste and odor control which constitute virtually a digest of the most recent work along these lines.

The chapter on Corrective Treatment, with its illustration of recording pH equipment used at Baltimore is one of the most interesting and informative in the book. As a matter of historical accuracy the use of lime or soda as corrective treatment for corrosion dates much further back than 1922 as implied. The excellent paper by the late Professor George C. Whipple in the 1913 Proceeding of the New England Water Works Association deals with this subject ably.

Of the three tables contained in the appendix the first might be extended with advantage to cover a wider range of dosage commonly encountered and might also with advantage include the equivalent parts per million which unit is frequently referred to in the text. The second table of the appendix giving the equivalent measures of filtration rates seems better adapted to slow sand filters than rapid sand filters. An extension of the table to include values per minute would be helpful to the rapid sand filter operator, who is accustomed to note the drop per minute in filtering, and the rise per minute in washing.

Errata in this first edition are few. On page 42 the equivalent of 125 m.g.d. should be 350 sq. ft. per m.g.d. instead of 360; on page 86 "determent" should be "detriment"; on page 81 "bacteral" should be "bacterial."

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Athens Makes Use of Ancient Aqueduct

When Greeks and Romans builded, it was for permanency. The new water works for the city of Athens, constructed under the direction of an American, Richard M. Merriman, of Bethlehem, Pa., includes in its system the ancient Hadrian Aqueduct, a fifteen mile tunnel through the Plains of Attica.

This aqueduct, apparently, was originally constructed during the second century after Christ. It was used for 1,200 years, but was then abandoned for some unknown reason. It has now been cleaned and renovated, and through it flows water for the citizens of Athens who for centuries have scrimped along on one and one-half gallons of water a day per person for all purposes.

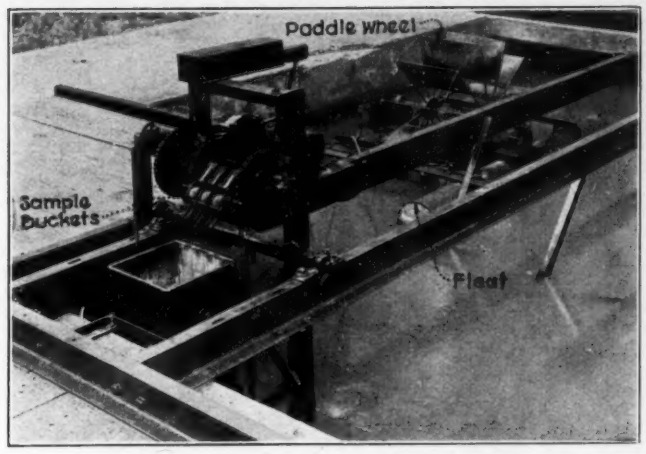
The water works themselves occupy the site of the historic Battle of Marathon. Marathon Dam was constructed in five years at a cost of $12,500,000. This, however, was 19 miles from Athens. The Parnes Divide was crossed by an eight mile tunnel and the Hadrian Aqueduct utilized for the remainder of the distance.

In a future issue of WATER WORKS AND SEWERAGE there will appear a description of the Athens Filtration Plant by L. A. Geupel, Water Purification Engineer, Societe des Eaux, Athens.

AN AUTOMATIC SEWAGE SAMPLER

By C. E. KEEFER

Principal Assistant Engineer,
Bureau of Sewers, Baltimore, Md.



A Sewage Sampler Installed

A WELL-EQUIPPED sewage works laboratory, operated by a trained personnel, should offer every facility for obtained accurate analyses of crude and treated sewage. The work, however, loses most of its value if the samples obtained are not truly representative. The collection of samples of the sewage, therefore, should be made several times daily. Furthermore, where the flow is considerable, two or more samples should be taken from different points or elevations at each sampling station in the sewage channel as the concentration and the character of solids vary with the velocity. The collecting of samples becomes a time consuming task at a treatment plant that covers a large area, such as the one in Baltimore, where the sewage is collected from stations some of which are over a half a mile apart.

In order to simplify this problem an effort has been made during the past two or three years at the Baltimore Sewage Treatment Works to obtain an automatically operated sampler that would work satisfactorily. Two different ones were tested over a considerable period of time, but neither proved acceptable. The observations made of this equipment indicated the following to be some of the important features to consider in the design of sewage samplers: (1) the apparatus should be built so that it will not stop operating in winter due to the freezing of sewage or spray around the moving parts; (2) the cost of the equipment should not be high; (3) it should be made of durable materials to withstand corrosion; (4) the sampler cup and parts, through which the sewage flows, should be designed so as to be easily cleaned, and should be such that the possibility of organic growths forming and later sloughing off is reduced to a minimum; (5) the quantity of sewage collected should be proportionate to the volume passing through the plant; (6) and where the flow is large, samples should be obtained from different points or elevations in the channel at each sampling station.

Another View of Sewerage Sampler Installed at Back River Sewerage Treatment Works

Based upon a careful study of the above-mentioned features a sampler was designed for use at the Baltimore plant by the General Engineering Co., who specialize in making this type of equipment. This machine was put in operation in June, 1932, and up to the present time has proved satisfactory. It was placed in the effluent conduit from the preliminary settling tanks, which is 12 ft. 6 in. wide and 13 ft. 6 in. deep. The average flow in this channel is about 60 m.g.d. with a minimum flow of approximately 35 m.g.d. and a maximum of 120 m.g.d.

The equipment consists essentially of two parts. The first part includes the sampler proper, comprising an angle framework, which supports the sample cups and an electric motor with an interconnecting gear and drive chains. This framework hangs suspended vertically in the sewage, and is supported by small steel cross-beams, which are bolted to the top of the sewage channel. The frame is pivoted at the top so that by raising the lower end the whole apparatus can be lifted free of the sewage for examination or repair. The second part of the equipment is a paddle wheel, which starts the motor on the sampler.

The machine is designed to collect three samples during each cycle of operation: one near the surface of the sewage, the second at a mid-depth point, and the third near the bottom. The container, which collects the sample, consists of three bronze cups, each 2¼ in. long and ⅞-in. in diameter with a capacity of about 22 cc. The top of each chamber is covered by a 1½-in. bronze sphere, which prevents the entrance of sewage except at a pre-determined time. The container is suspended between two endless chains, which pass over sprockets, two of which are at the top of the sampler above the

sewage, and the other two at the bottom near the invert of the sewage conduit. The sprockets, which drive the chains, are operated through a 60:1 speed reducer by a ¼-h.p., 1800-r.p.m. electric motor.

The operation of the sampler, which is controlled by the speed of the paddle wheel and in turn by the velocity of the sewage, is intermittent. When not operating, the sample cups hang suspended about two feet above the sewage. When the electric motor is put in service after a given number of revolutions of the paddle wheels, the container moves vertically downward. At a point about 2 ft. below the surface of the sewage a rubber trip engages the sphere resting on the top of one of the chambers or cups, momentarily raising the ball off of its seat. The sewage sample flows into the chamber, and the sphere again falls to the top of the cylinder, thus preventing the entrance or escape of sewage. As the sampler continues downward, the other two chambers are similarly filled, the one 6 ft. and the other 10 ft. below the surface of the sewage. The collector cups then return upward, and the sample is emptied into a suitable receptacle. At this point the electric circuit to the motor is opened, the sampling cups come to a stop, and take the position they had at the beginning of the operation.

The paddle wheel, which is used to close the electric circuit to the motor, is kept in motion by the sewage. The wheel is made of sheet brass, and is supported by two water-tight metal floats. After the wheel has made a definite number of revolutions, the electric circuit, connecting the motor with main source of power, automatically closes. The motor then operates until the sampler has made one cycle, when the circuit is opened. This operation is then repeated after the wheel has again revolved a definite number of times.

As the speed of the paddle wheel increases with the velocity of the sewage, the amount of sample collected and discharged into the sampling bottle is greater with higher flows. The amount of material collected during 24 hours varies from about 2,300 to 3,700 cc. Tests made with the equipment indicated that the paddle wheel is sufficiently sensitive to revolve when the velocity of the sewage is as low as 0.3 ft. per sec.

At the Baltimore treatment works it will be necessary for the sampler to be out-of-doors. Its construction, therefore, is such that the sewage sample can be kept from freezing in winter by burning one or two electric lights, placed near the receptacle for the sample. It is proposed to install the existing machine at the different sampling points at the treatment plant to see how it will work under various conditions. It will also be observed during the winter to make sure that freezing weather does not interrupt its operation.

The sewage works is under the general supervision of B. L. Crozier, Chief Engineer, Department of Public Works, and George E. Finck, Sewerage Engineer, with G. K. Armeling, Superintendent.

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AN ERROR IN IDENTIFICATION.—In reporting the meeting of the Pennsylvania Sewage Works Operators' Association in WATER WORKS AND SEWERAGE for August, the picture taken during the meeting at State College of L. W. Monroe, Retiring President of the Association, was erroneously labeled L. S. Morgan, District Engineer of the State Department of Health. Mr. Monroe is Boro Manager of Ellwood City, Pa., and we take this opportunity of correcting our error.

New York University Offers Course in Sanitary Engineering

Plans of considerable magnitude in respect to development of Sanitary Engineering Courses have been made at New York University with the opening of the present college year on September 19th.

Professor Thorndike Saville, professor of Hydraulic and Sanitary Engineering at the University of North Carolina, has been selected to take charge of this new department in the College of Engineering. Professor Saville who has also been chief engineer of the North Carolina Department of Conservation and Development, is widely experienced in the requirements of his particular field.

From 1907 to 1910, while a resident of the Canal Zone, he became familiar with all classes of work on the Panama Canal. Following two years of service as a First Lieutenant in charge of design and construction of sanitary works in the United States Army, he visited England and France to investigate river regulation and sewage treatment processes. In 1926-27 he was Consulting Engineer to the Government of Venezuela on water supply for Caracas. In 1929 he was Consultant to the Board on Beach Erosion, United States Army Engineers, and in 1930 he was made a member of the Board. Since 1920 he has been Chief Engineer of the North Carolina Geological Survey and its successor, the North Carolina Department of Conservation and Development, in charge of the Water Resources Division.

Arrangements have been made with the Graduate School of New York University whereby the degree of M. S. will be granted for post-graduate work in Sanitary Engineering.

These courses will be inaugurated during the coming college year of 1932-33 and a few specially qualified men will be accepted. It is believed that the initial work can be adapted to the qualifications of the student to greater advantage than by immediately setting up a definite curriculum. To give an idea of the character of studies involved, assignments may be made from the following groups:

Required Courses: Advanced Hydraulic & Sanitary Engineering, Sanitary Engineering Laboratory, Sanitary Engineering Design, Hydrology, Regional and City Planning, Research in Hydraulic & Sanitary Engineering.

Elective Courses: Water Power Engineering, Advanced Hydrology, Colloid Chemistry or other Chemical Option, Public Health Administration, Municipal Government, Business Combinations, Statistical Technique, Seminar in Problems of Water Conservation.

It is planned for another year to have a "Sanitary Option" in the Senior Year for undergraduate students in Civil Engineering whereby certain more or less specialized courses in other fields will be replaced by courses in Hydraulic and Sanitary Engineering.

It is believed that the future demands for highly specialized training in hydraulic and sanitary engineering justify the establishment of specialized facilities for graduate study and research, particularly in the great metropolitan center of New York.

The new work which New York University will begin to develop this year is expected to provide opportunities not only for training engineers for such public agencies as Municipal Water and Sewerage Departments, State Boards of Health, Conservation Commissions, and similar bureaus, but to make available laboratory and research facilities where special problems in sanitary and municipal engineering confronting the state, municipalities, and industries may be cooperatively investigated in a scientific and unbiased manner.

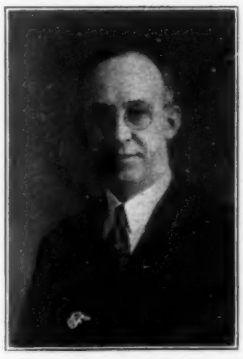
INDUSTRIAL WATER SUPPLY ·AND TRADE WASTES·

TREATMENT OF CIRCULATING WATER FOR COOLING PURPOSES

By CHARLES P. HOOVER

*Consulting Chemical Engineer,**
Columbus, Ohio

THIS article tells about two personal experiences in producing satisfactory water for circulating purposes, one at a glass plant and the other at a sulphuric acid plant.



C. P. Hoover

Producing Satisfactory Circulating (Cooling) Water for a Glass Melting Tank or Furnace

The glass plant referred to makes sheet glass and uses a continuous glass melting tank or furnace constructed of silica and clay refractories and is about 100 ft. long and 25 ft. wide. The clay material forming the tank containing the batch of glass disintegrates very quickly at the glass line of the tank because it is here that the erosive action of the molten glass is the greatest.

This disintegration at the glass line is so serious that the furnace can be operated for a short time only unless protective measures are used. The furnace referred to is protected at the flow line by a pipe radiator system through which cold water is circulated. The radiator device is laid against the outside wall of the furnace and is placed to extend slightly above the glass line. It is built in sections of convenient lengths of six one inch pipes laid parallel one above the other and added to the furnace as the clay work erodes away, in time covering a large portion of the tank wall. When the brick work at or near the glass line breaks or disintegrates, the molten glass comes in contact with the cooler pipes, crystallizes or forms walls of glass which stop up the opening. This protective scheme keeps the furnace from going to pieces at its most vulnerable part and as a result of this the furnace can be operated for a period of about 18 months before it is necessary to rebuild it.

Originally, very hard well water having a high alkalinity due to calcium and magnesium bicarbonates, was pumped through the cooling pipes at this plant. On account of the high mineral content of the water, it was not satisfactory. The calcium and magnesium compounds were deposited in the pipes as an adherent scale which clogged them very badly.

The furnace becomes so hot that if the flow of water in the cooling pipes stops for several seconds, the pipe burns through which permits a flow of water into the molten glass, resulting in the formation of seeds or bubbles in the glass, thus temporarily spoiling the entire lot. So much glass was spoiled due to leaks in the water cooling system when the hard raw water was used that it was decided to install a water softening plant. A lime-soda plant was installed but the softened water was not carbonated. The uncarbonated softened water continued to build up scale in the circulation system and therefore did not solve the trouble. The unsatisfactory results obtained with the lime-soda softened water led to its abandonment.

A zeolite softening plant was installed. The circulation water with this treatment was softened to zero hardness. The zero hardness water soon freed the coils from scale but after all the scale was eliminated, a new trouble developed due to the water being corrosive, the pipes became clogged with a formation of iron nodules. The corrosion and formation of nodules caused clogging which was followed by a burning out of the pipes and leakage of water into the glass.

After having tried raw water, lime softened water and zeolite softened water, the company asked us for a report on a treatment process that would eliminate scale formation and corrosion. The process reported on and adopted was as follows:

The raw water was first softened with lime in the lime-soda softening plant. It was then partially carbonated and filtered through a sand filter. Part of the lime softened water was then passed through the zeolite softener. Enough of the lime softened water, containing calcium carbonate, was then mixed with the zero hardness zeolite softened water so that the mixed water would have about 25 to 30 parts per million of calcium carbonate. This is enough to effect chemical equilibrium or chemical balance to calcium carbonate (to be described later) and produce a non-corrosive water, that is, it is non-corrosive in a cooling system where the temperature is under 150° F. and where the pH of the water is kept around 8.6 to 8.8. More calcium carbonate is required if the pH is lower, and slightly less calcium carbonate is required if the pH is higher. The pH of the mixed water was adjusted so as to stabilize it or give it chemical balance to calcium carbonate, and this was accomplished with soda-ash if the pH was too low, and, with CO_2 gas if it was too high.

Whether or not the water is in chemical balance to calcium carbonate can be easily and quickly determined. To carry out the test in a practical way where extreme accuracy is not required, the procedure is as follows: Divide the sample of water to be tested into two parts. Determine the alkalinity to methyl orange on sample No. 1 and record the result obtained. To sample No. 2, (say 150 c.c.) add a considerable excess of powdered C.P. calcium carbonate, heat to temperature that water attains in circulating system, stir for a few minutes, settle, filter

**Chemist in charge, Water Softening and Purification Works, Columbus, O.*

and determine the alkalinity. If the alkalinity of sample No. 2 is higher than the alkalinity of sample No. 1, the result shows that the water is under saturated. If the alkalinity is exactly the same on both samples, this indicates that the water is neutral to calcium carbonate, that is in equilibrium or chemical balance. If on the other hand, the alkalinity of sample No. 2 is lower than the alkalinity of sample No. 1, then the sample is super-saturated with calcium carbonate.

Generally speaking, water, super-saturated with calcium carbonate as determined by this test, when passed through a circulating system, will deposit scale. Water undersaturated, will be corrosive and water in chemical balance will neither deposit scale or be corrosive.

By adjusting the chemical balance to calcium carbonate, water may be made to deposit a thin protective film of calcium carbonate and on account of the fact that the circulation system in this particular case was in a corroded condition when the new treatment process was adopted, it was decided to treat the water temporarily so that it would be super-saturated with calcium carbonate.

Removable test sections of the cooling system were installed and these were examined every few days after the new treatment was started. At the end of two weeks the interior of these test pipes looked as though they had been whitewashed. The metal was protected by a thin film of calcium carbonate and on account of this protective film, water passing through the pipes could not come in direct contact with the metal and corrode it. The problem then became one of treating the water so that it would not build up additional deposits or dissolve that which had already been formed.

Experience at this plant has demonstrated that this can be satisfactorily done. Frequent chemical balance tests were made by the plant operator. If the results of the tests showed super-saturation, the CO_2 was increased and, if, on the other hand, the results showed undersaturation, the application of soda-ash was increased.

The CO_2 was produced by burning natural gas in a stove made out of an abandoned hot water heater and the CO_2 was cooled in a second tank, (see Fig. 1) after which it was forced by a blower through diffusers into the water. The soda-ash was applied as a solution in measured portions.

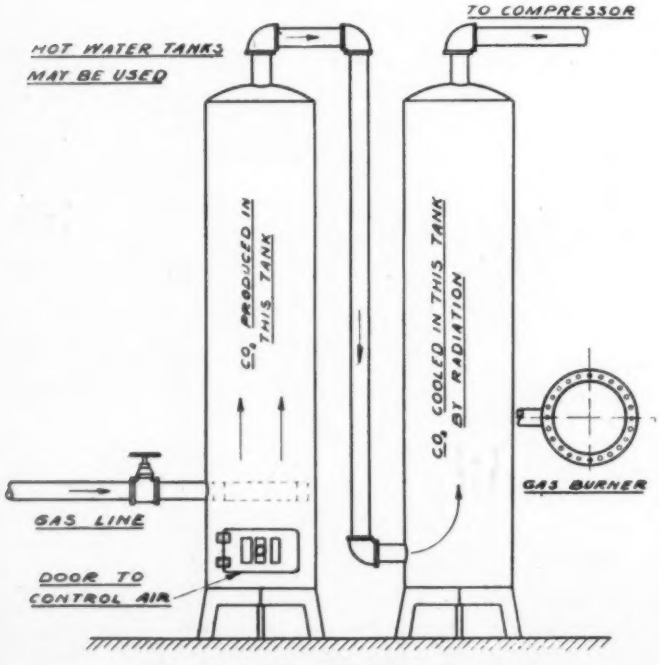

TO COMPRESSOR
HOT WATER TANKS MAY BE USED
CO₂ PRODUCED IN THIS TANK
CO₂ COOLED IN THIS TANK BY RADIATION
GAS BURNER
GAS LINE
DOOR TO CONTROL AIR

Fig. 1.—Gas Burner Carbonation Plant

Circulating Water for Cooling Coils in a Sulphuric Acid Plant

At a sulphuric acid plant, extremely hard well water having an alkalinity of 400 and a total hardness of 650 parts per million, was circulated through lead coils to cool the hot acid. The calcium and magnesium bicarbonates in the water were broken down by heat and deposited as an adherent scale in the coils. As a result of this the coils had to be reamed out about every 30 days. This was a tedious and expensive procedure. It was so burdensome that the owners considered installing a water softening plant to remove the calcium and magnesium bicarbonates from the water. This involved a sizable investment and a high annual operating charge. Results of chemical balance tests made on this water showed that it was highly super-saturated with calcium and magnesium bicarbonates. It was decided to attempt to reduce the pH of the water with sulphuric acid to the point where the carbonates of calcium and magnesium would be in chemical balance. It was known that if enough sulphuric acid was added to convert all of the calcium and magnesium bicarbonates to sulfate, that scale would not form in the lead coils but this made the water corrosive and it was necessary that the water be treated so that it would not be corrosive because it was pumped by iron pumps and conveyed to and from the lead coils into the cooling tower and pond through iron pipes.

It was found after several trials that chemical balance could be maintained and non-scale forming, and non-corrosive water suitable for circulating purposes could be produced from the hard well water supply by adding enough sulphuric acid to the supply so as to keep the alkalinity in the pond water down to a figure between 80 and 100 parts per million. The test for chemical balance described previously in this article was used to determine the extent of acidification required.

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Chemical Precipitation at Worcester, Mass.

In the August issue of Water Works and Sewerage, Mr. E. Sherman Chase of Boston was credited with the statement that the use of the chemical precipitation process at the Worcester (Mass.) Sewage Treatment Works during its early life had resulted in a removal of 80 to 90 per cent of the organic content of the sewage. This statement appears in the report covering the meeting of the Pennsylvania Sewage Works Association.

Mr. Chase has since corrected the statement by letter which discloses the following recorded removals by the Worcester plant in 1894. Precipitation of solids was secured by use of the lime-iron process as understood in that period.

	Average Removals
Suspended matter	92.17%
Suspended albuminoid matter	89.54%
Total albuminoid matter	50.78%

The total organic matter removal was plainly less than the erroneously reported 80 to 90 per cent, whereas the removal of *suspended* organic matter was approximately 90 per cent and suspended solids removal averaged better than 90 per cent for the year.

It was the above figures that Mr. Chase was attempting to give from memory in an extemporaneous reply to a question from the floor and therefore subject to confirmation which, in the interest of accuracy, we are pleased to print in the nature of a correction.

ROUTINE WASTE SURVEYS

By E. T. CRANCH
Superintendent, New Rochelle Water Co., New Rochelle, N. Y.

IN any plant where economy of operation is necessary, it is most essential to carefully watch the ratio between total water consumed and total water paid for. Where water is sold at a flat rate, it is of course impossible to determine such a ratio with any degree of accuracy. If there are no master meters it is difficult to arrive at an accurate figure even though the individual consumers are 100 per cent metered.

At the present time there seem to be about as many methods of figuring "accounted for water" as there are superintendents of water works. We believe that by "accounted for water" only such water as is registered on consumers' meters should be considered. We do not believe that any estimated amount of so-called "free-water," or water used from fire hydrants for fires, or flushing or any other purpose should be included in the figure used for "accounted for water." At best such an estimate can be only a guess and one man's guess may vary considerably from that of another.

On such a basis as above, we believe that 80 per cent accounted for water is about as good as can normally be expected. We realize that some cities claim much higher percentages and in others the percentage is very much lower.

In New Rochelle waste surveys had been made by the Pitometer Company every year or two. Their surveys always more than paid for themselves by the discovery and elimination of many underground leaks. A Pitometer survey of this kind however always caused considerable woe to the operating department. The territory was divided up into districts, all valves were shut on the boundaries of such district to see if a tight cut off could be obtained and then such district would be fed for 24 hours or more through one small pipe in order to obtain sensitive readings of the Pitometer. This would always cause a stir-up in the mains. Result: many a fond mother calling up to inform us that she couldn't give the baby the filthy water coming from the pipes, and many a housewife demanding that we pay them for the clothes they had ruined in the wash.

Secondly: the above method of segregation would cause a material reduction in pressure in the segregated area. Result: Indignant business men calling up to say they couldn't get enough water for a shower, and superintendents of apartment houses notifying us that they couldn't get any water on the top floors.

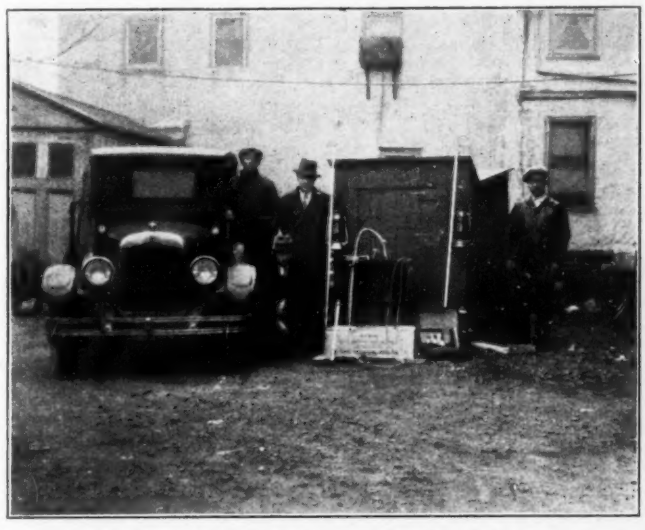
Thirdly: The danger of a fire starting in the segregated area.

Therefore, even though the Pitometer Company saved us money by cutting down our waste of water we always hated to send for them and would welcome their departure with a sigh of relief.

In order to overcome the above difficulties and likewise to secure even a closer check on our water waste we have developed our own Pitometer crew. A picture of this crew is here shown. The personnel consists of two pitometer men and two laborers. The equipment consists of two Cole pitometers, one indicating and one recording, the necessary calipers, etc., in conjunction with these instruments, two portable pitometer shelter houses and a light half-ton truck.

The same areas of subdivision and same points of measurement are used as before with this important difference that all the work is done at night. If the area to be shut off is large we may start closing valves at about 9 p. m. but the actual work of measurement will not start before one or one thirty in the morning and we endeavor to have the whole system back to normal by 5 o'clock. This generally gives time for the water to settle before many people start using it in the morning. With this method of operation, which has been in use now for over three years, we have had very few complaints from our customers. Our pitometer men have also become so familiar with the rates of flow to be expected at the various stations that we have been able to locate leaks with a minimum of lost motion and time. After the leak has been approximately located in this manner we have generally been very successful in determining its exact location by means of the geophone.

The Pitometer Crew is not continuously at work on



Pitometer Crew of New Rochelle Water Co.

leak surveys but only goes out when our minimum night rate of flow shows an unaccountable increase. A leak of sufficient size to show on the night rate is usually caused by a broken or cracked pipe. There is another source of leakage which is important but usually is not large enough to materially affect the night rate, namely, leaking services. In order to discover these quickly our meter readers as a matter of routine test all services with the aquaphone as they read the meter. In this way we have caught a considerable number of service leaks. We believe results have well justified the extra time spent on meter reading which the check-up for service leaks entails.

The following table will illustrate briefly what has been accomplished:

Year	Number of Leaks Repaired		Total Consumption in Gallons	Per Cent of Total Consumption Accounted For
	Mains	Services		
1928*	82	131	2,287,874,000	64.1
1929	54	128	2,282,611,000	73.6
1930	46	157	2,330,172,000	78.7
1931	44	150	2,433,621,000	79.2

*During 9 months only.

The last regular survey was made by the Pitometer Company in 1928. In the course of this survey a considerable number of leaks were discovered in both mains and services. Also in the year 1928 there was an unusual amount of drainage and highway work going on in the territory served and several times mains were broken by adjacent blasting operations. It was immediately after the 1928 survey that our own Pitometer Crew was organized.

One other factor worthy of mention in increasing the percentage of accounted for water is the amount of detailed attention given to bringing up the condition of consumers meters so that they measure as nearly as possible all the water passing through them. This feature was covered in an article by the writer in WATER WORKS AND SEWERAGE—April, 1932.

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Informing Water Works Visitors and Consumers

By S. D. POARCH

Superintendent Board of Water Commissioners

S. D. Poarch

The visitor to the Water Purification Works at Olean, N. Y., is handed an instructive and informative statement which tells concisely what the Water Department is doing in order to serve the community with wholesome and pure water in the proper quantity and under required pressure. One, reading in the leaflet, can but be impressed that S. D. Poarch, Superintendent, and the Water Works personnel of Olean are abreast of modern developments and that Olean citizens have nothing to expect in the way of an apology from their Water Department.

The wording of the leaflet follows. The idea is worthy of consideration as a publicity feature by Water Departments elsewhere.

RESPONSIBILITIES OF A WATER WORKS

1. To furnish water under sufficient pressure and in sufficient quantities at all times, because fire is the city's greatest enemy.

2. To furnish water of a safe sanitary quality, because disease is second only to fire as our greatest enemy.

3. To furnish water of good physical quality (clear, sparkling and colorless).

4. To furnish water free from objectionable odor, a responsibility keenly felt, which is receiving the attention of most of the research workers.

WHAT IS BACK OF THE FAUCET IN THE OLEAN HOME?

1. Sixty miles of pipe in the distribution delivering water for fire protection in addition to the city's industrial and domestic wants.

2. Two reservoirs with a total capacity of 12 million gallons maintaining sufficient pressure for fire fighting.

3. A strictly modern water purification plant capable of furnishing six million gallons of water daily, or 4,168 gallons per minute, using the following methods:

a. Prechlorination, to kill bacteria and to cheapen the treatment in the matter of the amounts of chemicals needed.

b. Aeration, to remove the major part of the odors.

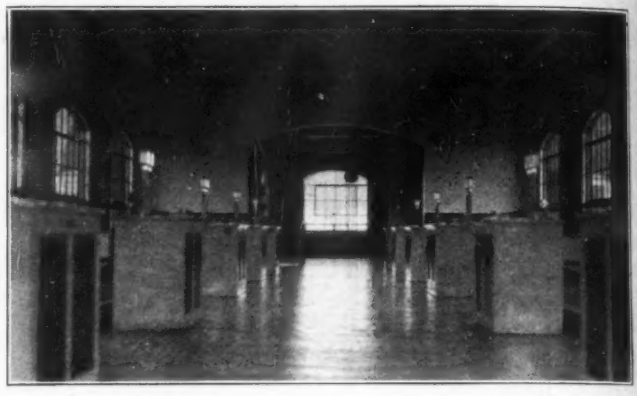
c. Coagulation with alum and lime to remove the major part of the silt and bacteria, and deodorization and taste removal with activated carbon.

d. Filtration, through 30 inches of sand and 24 inches of graded gravel, to remove all silt and bacteria.

e. Final sterilization, to insure a product of absolute safe sanitary quality.

4. A thoroughly trained and capable personnel to operate the system, including:

a. Men who do the mechanical work in the system, and make taps of all sizes while the mains are under pressure.



Interior of Filter Building, Olean, N. J.

b. Men who operate this plant 24 hours out of the day, 365 days out of the year.

c. Men who are continually working to improve methods of production and quality of product.

5. A thoroughly reliable system of reports to the health authorities for your protection, including:

a. Daily telephone reports to your city Health Officer.

b. Complete daily reports to a member of the Board of Water Commissioners, to the city Health Officer, and to the County Health Commissioner.

c. Complete monthly reports to the State Department of Health.

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Water Supply and Sewerage for Chicago World's Fair

Water pumping and sewage systems sufficient to meet the requirements of 1,000,000 persons a day are being provided for A Century of Progress Exposition—Chicago's 1933 World's Fair.

The water pumping system which will draw its supply from the water tunnels of Chicago will consist of pumping stations with a capacity of 28,000,000 gal. a day, with a pressure ranging from 75 lb. at the station to 25 lb. at 39th street, the southernmost limits of the grounds. Thirteen miles of water pipe will be required.

The sewage system will comprise four pumping stations with a combined capacity of 22,500 gal. per minute and seven miles of pipe. The sewage will be pumped to the sewage mains of the city of Chicago. Two of the pumping stations are already in operation and the other will soon be constructed.

Bids have been taken for the construction of the water pumping station and it is expected it will be in operation by Nov. 1, 1932.

A TWO-STORY TANK WITH PRE-CHLORINATION

By WALDO S. COULTER

Consulting Engineer,
New York City

OWING principally to operating difficulties with two-story tanks, the trend for the past few years has been definitely toward plain sedimentation, with the mechanical removal of sludge and artificially controlled separate digestion. Arguments for separate digestion were the absence of troublesome foaming, shallower and cheaper tanks and a complete separation of the sedimentation and digestion processes.

Separate digestion has become increasingly elaborate—requiring sludge pumps; stirring devices; floating covers; gas-heated water systems; intricate piping; additional tanks for the storage of sludge between digesters and drying beds to concentrate the sludge and improve the quality of the supernatant liquor; multi-stage digestion; sludge pre-heaters and other features. All of these have contributed in one way or another to bring about a fairly complicated process. A separate digestion plant may now cost as much or more than a two-story design.

In separate digestion the separation of the sedimentation and digestion processes is not as complete as is desirable. Supernatant liquors from the digesters, having a large solids content and an excessive oxygen demand, remain to be disposed of. Usually this liquor is added to the settling tank influent, i. e., crude sewage. It is bad practice to discharge supernatant liquor into the influent of the aeration tanks of an activated sludge plant and where pre-chlorination is not practiced, septic action may become sufficiently pronounced in plain sedimentation tanks to reduce their efficiency, even though mechanical cleaning is practiced.

I do not wish to be understood as arguing against separate digestion plants, of which I have designed a number. They have obvious advantages, but I do believe that the simpler designs should not be dropped as one abandons a worn-out car. The two-story tank should not be branded, as it sometimes is, as an antiquated trouble maker and not subject to worthwhile improvement.

An example of a two-story installation of modern design, with pre-chlorination, that has operated with good results and none of the usual Imhoff difficulties is the plant of the Clara Barton District, Raritan Township, New Jersey. This plant was placed in operation in May, 1930, and has a capacity for 6000 persons. It was designed by the writer and constructed under the supervision of Raymond P. Wilson, Township Engineer, with general supervision by the designer. The contractor was the Suburban Engineering Co. of New York.

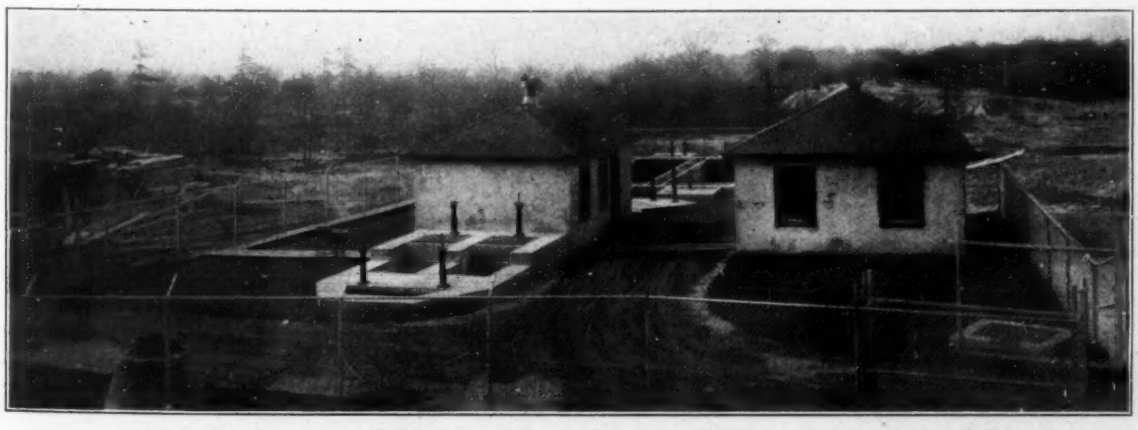
The plant consists of coarse bar screens; pre-chlorination equipment located at the screen chamber; measuring and dividing weirs; a rectangular two-story tank with two settling compartments; and uncovered sludge drying beds.

The chlorinators are of the solution-feed type and the chlorine water is admitted to the sewage through a hard rubber manifold equipped with flexible rubber tubes entering the sewage.

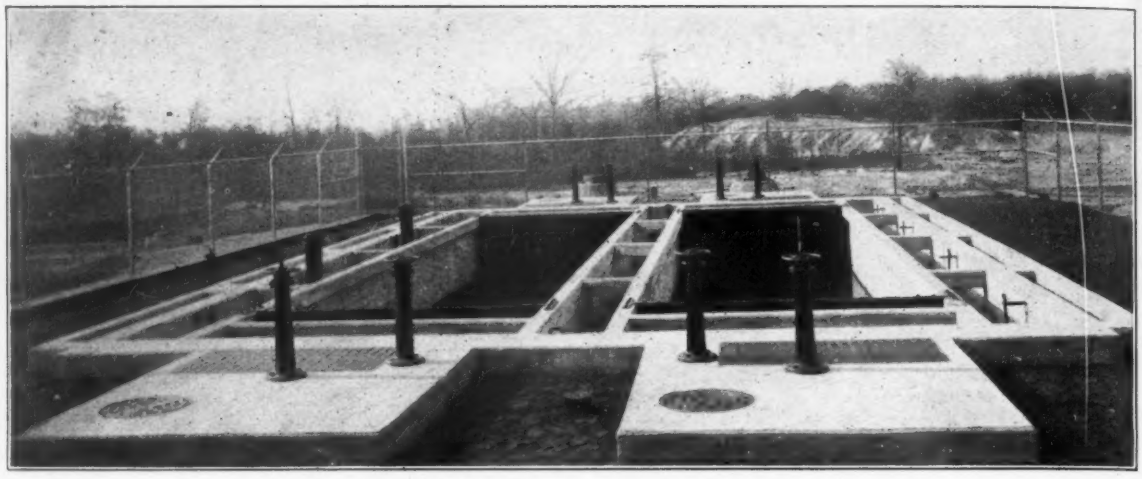
The influent is admitted to the settling tank through reversible high-velocity inlets operating in conjunction with lattice baffles. There are no influent or effluent troughs. Aside from these features, the flowing-through compartments are of conventional design, the slot being trapped by a triangular beam. The inside length of each chamber is 47 ft. 2 in.

The side gas vents are paralleled by scum troughs with which the vents are connected by gated openings. These troughs are connected to the sludge drains leading to the drying beds. The middle vent has a gated scum opening at each end. The tank has a maximum water depth of 28 ft. 4 in.

The digestion compartment forms a single chamber extending under both settling chambers, without a longitudinal wall and the bottom forms a single trough, without pockets. Transverse walls each have openings about 12 ft. high and 20 ft. wide. The sloped floor is provided with perforated water pipes having discharge nipples to direct jets downward parallel to the slope.



Screen Chamber, Tool and Weir House and Chlorination Building. Tank in Background.



Close-up of Two-story Tank

The net sludge capacity is about 2 cu. ft. per capita. The sludge drying beds comprise four units having a combined area of 1.5 sq. ft. per capita.

In operation, this plant has consistently given a well clarified effluent. There has been no foaming and solids have not risen through the slots. Scum formation has been negligible and a thick, black, well digested sludge, impregnated with gas bubbles, has been regularly produced. Very little attention is required to keep the flowing-through chambers entirely free of floating material.

Gas production is vigorous at all times, even in mid-winter. Soundings show a very even distribution of sludge deposits in the digestion chamber. When drawing sludge, it is necessary to use the perforated water pipes for a few moments before opening the sludge valve. The withdrawal of sludge is accompanied by no disturbances in the settling compartments.

The effluent of the Clara Barton plant is equal to that of any separate digestion plant I have seen, and the sludge is as completely digested and much less watery. The plant requires very little attention.

There is at times some odor of low intensity in the immediate vicinity of the gas vents, but it is localized to within 50 ft. or so of the tank. No objectionable sludge bed odors have been experienced, although it probably would be advisable to provide covered beds in a less isolated location.

I am inclined to believe that the success of this plant is due primarily to the effects of prechlorination and secondarily to the use of high-velocity inlets with lattice baffles and the undivided sludge compartments without pockets.

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Association Meetings Scheduled

Sept. 22-23—CENTRAL STATES SECTION, AMERICAN WATER WORKS ASSOCIATION. 34th Annual Convention, Hotel Lawrence, Erie, Pa., Secretary-Treasurer, B. J. Lechner, Secretary, Commissioners of Water Works, Erie, Pa.

Sept. 26-28—NORTH DAKOTA WATER AND SEWAGE WORKS CONFERENCE. 4th Annual meeting, Minot, N. D. Secretary-Treasurer, A. L. Bavone, State Department of Health, Bismarck, N. D.

Sept. 27-30—NEW ENGLAND WATER WORKS ASSOCIATION. 51st Annual Convention, Hotel Kimball, Springfield, Mass. Secretary, Frank J. Gifford, Tremont Temple, Boston, Mass.

Sept. 27-30—NEW YORK SECTION A. W. W. A. Will meet jointly with N. E. W. W. A. at Springfield. Secretary R. K. Blanchard, 50 E. 42nd St., N. Y. C.

Sept. 29-Oct. 1—INTERNATIONAL ASSOCIATION OF PUBLIC WORKS OFFICIALS. Hotel Wm. Penn, Pittsburgh, Pa. Secretary, A. M. Anderson, 100 No. LaSalle St., Chicago, Illinois.

Sept. 30-Oct. 1—WEST VIRGINIA CONFERENCE ON WATER PURIFICATION. 7th Annual Conference, University of W. Va., Morgantown. Secretary, J. B. Harrington, W. Va., State Department of Health, Charleston, W. Va.

Oct. 5-7—MICHIGAN CONFERENCE ON WATER PURIFICATION. 10th Annual Meeting (7th Annual Conference), Medea Hotel, Mt. Clemens, Mich. Secretary-Treasurer, John M. Hepler, Michigan State Department of Health, Lansing.

Oct. 10-14—OHIO CONFERENCE ON WATER PURIFICATION. 12th Annual Meeting, Warren, Ohio, and at new Water Purification Plant of Mahoning Valley Sanitary District. Secretary, J. M. Montgomery, Pique, Ohio.

Oct. 10-13—SOUTHWEST WATER WORKS ASSOCIATION. 21st Annual Convention, Fort Worth, Tex. Secretary-Treasurer, Lewis A. Quigley, Superintendent Water Works, Fort Worth, Tex.

Oct. 13-14—MISSOURI WATER AND SEWERAGE CONFERENCE. 8th Annual Meeting Hotel Bothwell, Sedalia, Mo. Secretary-Treasurer, Herbert Bosch, State Board of Health, Jefferson City, Mo.

Oct. 14-15—NEW YORK STATE SEWAGE WORKS ASSOCIATION. Fall Meeting, Hotel Saranac, Saranac Lake, New York. Secretary-Treasurer, A. S. Bedell, State Department of Health, Albany, New York.

Oct. 17—NEW ENGLAND SEWAGE WORKS ASSOCIATION. Semi-annual Meeting, Hotel Stratfield, Bridgeport, Conn. Secretary, F. W. Gilcreas, 14 Beacon St., Boston, Mass.

Oct. 22-24—CONFERENCE STATE SANITARY ENGINEERS. Annual Meeting, Hotel Willard, Washington, D. C. Secretary-Treasurer, R. E. Tarbett, U. S. Public Health Service, Washington, D. C.

Oct. 24-27—AMERICAN PUBLIC HEALTH ASSOCIATION. 61st Annual Meeting. Willard Hotel, Washington, D. C. Executive-Secretary, Homer N. Calver, 370 Seventh Ave., New York City.

Oct. 24-26—INTERNATIONAL CITY MANAGERS' ASSOCIATION. Hotel Gibson, Cincinnati, O. Executive Director, Clarence E. Ridley, 923 East 60th St., Chicago, Ill.

Oct. 25-27—MISSOURI VALLEY SECTION AMERICAN WATER WORKS ASS'N. 18th Annual Meeting, Sioux City, Iowa. Secretary, E. L. Waterman, Prof. of Sanitary Engineering, University of Iowa, Iowa City, Iowa.

Oct. 26-28—ROCKY MOUNTAIN SECTION, AMERICAN WATER WORKS ASSOCIATION. 6th Annual Meeting, Denver, Colo. Secretary, Dana E. Kepner, Pacific States Cast Iron Pipe Co., 226 Continental Oil Bldg., Denver, Colo.

Oct. 26-29—CALIFORNIA SECTION, AMERICAN WATER WORKS ASSOCIATION. 13th Annual Convention, Coronado Beach Cal. Secretary-Treasurer, R. F. Brown, 336 East Market St., Stockton, Cal.

Oct. 31-Nov. 1-2—NORTH CAROLINA SECTION, AMERICAN WATER WORKS ASSOCIATION. 12th Annual Meeting, Hotel Robert Lee, Winston-Salem, N. C. Secretary-Treasurer, H. G. Baity, Prof. Sanitary Engineering, Univ. of N. C., Chapel Hill, N. C.

UPWARD FILTRATION AND SLUDGE INCINERATION*

By WILLEM RUDOLFS[1] and S. F. HAY[2]

Dr. Rudolfs

INTEREST in mechanical sewage treatment is rapidly gaining. Experiments on sludge dewatering by centrifuges, chemical conditioning and filters, sludge drying and incineration are being made at a number of places. A method of removing suspended solids by slag filters, dewatering, drying and incineration of sludge was studied over a period of a year under a grant of the Mechanical Sewage Disposal Corporation and with the cooperation of the Isbell-Porter Company, which designed the plant and incinerator, was reported upon in more or less detail in the May, 1932 issue of the Sewage Works Journal under the title of "Sewage Filtration and Incineration of Sludge."

The method consisted briefly of tanks filled with a layer of commercial 1½-inch slag through which the raw (coarse screened) sewage was filtered upward. The sludge adhering to the slag was incinerated in an experimental calciner, receiving charges of from 250 to 300 pounds. The method produced results of about 70 per cent suspended solids reduction and from 55 to 60 per cent reduction in B.O.D. with an application of about 75 million gallons per acre per day. Temporary overloading to about 110 m.g.a.d. showed that the filters could stand it for a week or more, but would probably not be good practice. It showed, however, that daily fluctuations of 50 per cent increase in flow could be handled without difficulty.

**Journal Series paper N. J. Agricultural Experiment Station, New Brunswick, N. J., Dept. Sewage Research.*
(1) Chief, Dept. Sewage Research.
(2) Chief Engineer, Isbell-Porter Co.

A layout of a plant, based upon the experimental work done, is shown in figure 1. The layout consists principally of a series of movable filters to remove suspended solids and a two-stage incinerator, which calcines the sludge first and finally incinerates it. For treatment of a higher degree than 70 per cent suspended solids removal and 55 to 60 per cent B.O.D. reduction chemical treatment with mixing and settling tank are indicated; these tanks can be of any type. Most of the equipment is standard with the exception of the filter tanks and their connecting headers, while the incinerator is a development of a vertical retort made applicable to calcining and incinerating sludge. When a larger volume than 5 m.g.d. of sewage is to be treated the filter units are built proportionally larger.

Filters

The sewage enters the filter tanks from the bottom (fig. 2). The tanks are made of steel, with the inlet and outlet welded in. Each tank holds about 3 feet of 1½-inch commercial honeycomb slag with space above the top layer for a column of about 2 feet of effluent, which allows for a detention period of about 15 minutes. Considerable sedimentation takes place of finely divided material, which ordinarily will not settle in 15 minutes in a tank. These solids settle on the slag where they are held, in addition to those held within the layer of the slag. This combination of filtering and settling is interesting. On account of the distribution of flow through the slag the column of two feet of liquid in the tank is sufficient to prevent disturbances and washing of solids out of the tank. When the tank receives too great a flow of sewage, settling is retarded and in extreme cases even prevented with the result that the suspended solids in the effluent increase. Experiments have shown that the rate of flow must be persistently at least 50 per cent more than the design flow to produce these disturbances.

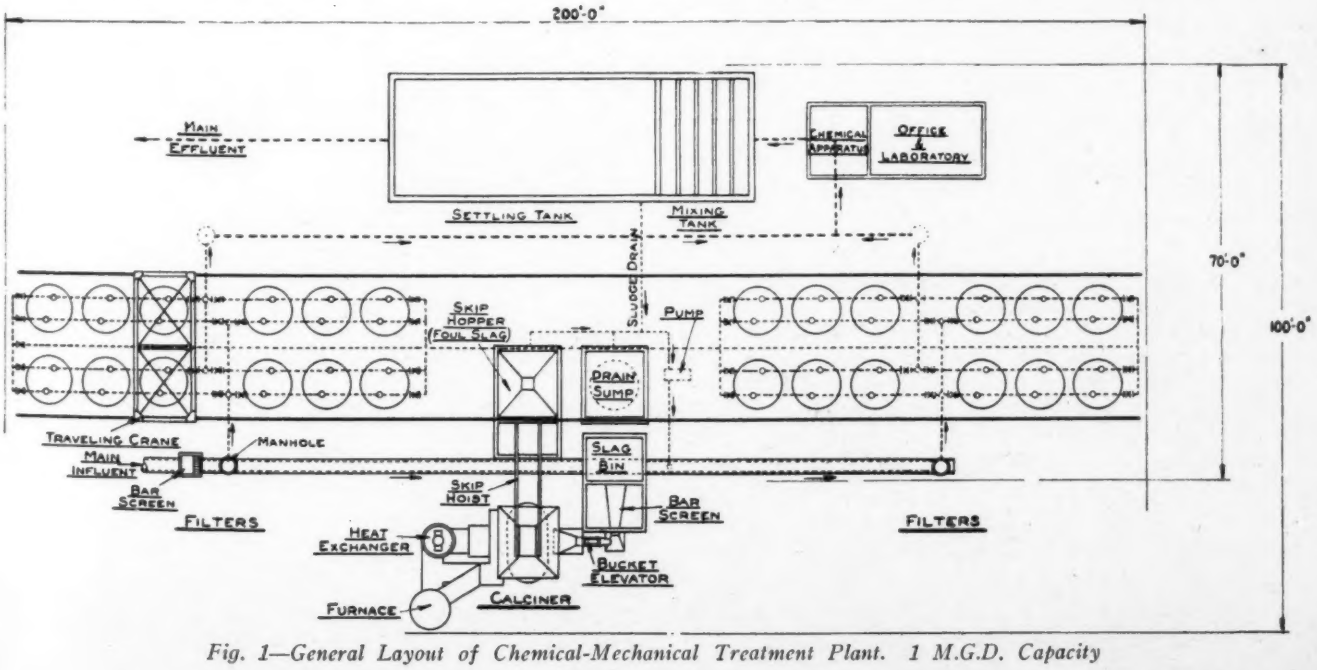

Fig. 1—General Layout of Chemical-Mechanical Treatment Plant. 1 M.G.D. Capacity

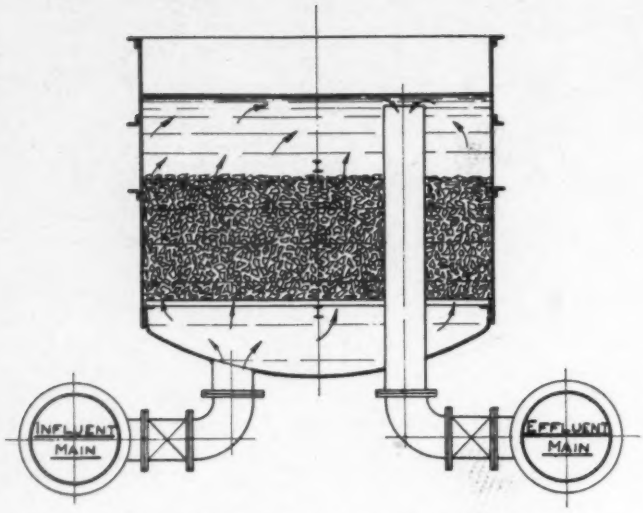

Fig. 2—Filter Unit Attached to Influent and Effluent Lines

The tanks are removable and each is held and guided to set in position on the inlet and outlet header connections. The weight of the tank automatically seals the connections. In addition the connections are adjustable to prevent leakage. The tanks are placed in series, one set for primary and another for secondary filters. When the primary filters have become partially fouled the raw sewage flow is shifted to the secondary tanks, so that the primary tanks become in turn secondary. This gives a reverse rotation and the mat of solids formed acts as a strainer for the finer solids. When the final filters are saturated with sludge to a point where the dry weight of the sludge equals approximately 8 per cent or more of the slag, they are allowed to drain until the free liquid has run off. It was found that the amount of sludge present in the slag was related to the increase in head in the filters. When the head increases a few inches the filters are considered to be "fouled" and ready for removal to the incinerator. The supernatant liquid of the "fouled" filters is returned to the primary filters and a crane picks up the drained tanks, carries them to the drain sump before being discharged into the hopper for the calciner. The distribution of the sludge through the slag allows dewatering to proceed rapidly with a resultant low moisture content (about 25 per cent) of the mixture. The time required for the sewage to pass the filter system is about one half hour.

Incineration

The incineration process as developed under the direction of the junior author consists of two parts: a drying and an incineration section. The mixture of sludge and slag is lifted from the drainage sump to the top of the incinerator and deposited in a hopper that feeds by gravity directly into the calcining or drying section. After partial drying it travels to the incinerator section where hot gases diluted with air burn the sludge (see Fig. 3). Hot waste gases with preheated air operating at about 800° F. are passed directly through the mixture of sludge and slag during the process. The relatively large interstices of the 1½-inch slag allows for large volumes ot air to pass and repass through, effecting a rapid incineration of the sludge. When the sludge content is about 8 per cent on the basis of the slag, the volatile matter from the sludge furnishes approximately 35 to 40 per cent of the fuel required. When the sludge content is higher the heat available is increased. The rest of the heat is supplied by oil through the aid of oil burners. The drying and incineration is accomplished by hot gases and not through direct contact of the flames from the burners, with the sludge or slag. Air, preheated by the exhaust gases, is used for combustion of the volatile substances coming from the sludge. Regulation of the air supply added after combustion keeps the mass at the desired temperature and the same regulation is used for odor control.

After incineration the slag and ashes are discharged into a hopper, run over a bar screen and thence back into the storage bin to be reused for filter material. Experiments have shown that about 2 per cent of the slag is disintegrated and can be screened out over a ½-inch screen. On a basis of 8 per cent dry solids in the slag this means that about half of the residue would be slag finer than ½ inch. The amount of ash to be expected per million gallons domestic sewage containing 200 p.p.m. suspended solids and with a removal of 70 per cent would be about 280 pounds or less.

Odors

In a system as described there are two possible sources of odors (1) from the filter tanks and (2) from the incinerator. The experiments have shown that if clean slag is used every few days no odors develop from this source, but there is a possibility that the tanks themselves become coated with a film of solids or growth which may decompose. For that reason means are provided for flushing the filter tanks periodically when they are dumped. Similar provisions are made to flush drains and feed lines. Odors emanating from the incineration of the sludge are principally controlled by the operation of the unit through temperature and air regulation. Utilization of the hot gases for preheating, drying and incineration produce results similar to a modern garbage incineration plant and further experimentation with activated carbon may lead to the removal of the last traces of odors. Cleanliness at a plant of this type is just as important as around any sewage treatment or garbage destruction plant. A system of flushing the concrete upon which the filters rest, drains and walks is provided.

Size of Plant

From the description it is apparent that the plant layout resembles an industrial plant more than it does an average sewage treatment plant. Although the plant is mechanical throughout the mechanisms are, as is the tendency in all modern treatment processes, rather simple. The area required for a million gallon plant is about 75 by 200 feet for a plant with 70 per cent suspended solids

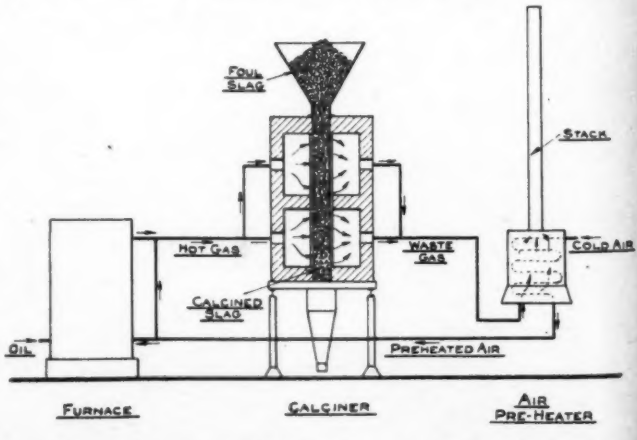

Fig. 3—Diagram of Pre-Drying and Incineration Unit

removal or with additional chemical treatment about 100 by 200 feet. A ten million gallon plant would occupy a space of about 200 by 350 feet.

Field for System

From the purificaion end it would appear at present, that the field for a system as described would be mainly between plain sedimentation and sedimentation plus trickling filters or activated sludge. There are many places where a higher degree of treatment than sedimentation is required and where trickling filters or activated sludge is not necessary. In such instances a system providing 70 per cent suspended solids removal would be appropriate. With the addition of chemical treatment to remove finely divided material and colloidal matter the system can be used for a higher degree of treatment to about 85 per cent suspended solids removal, 85 per cent B.O.D. reduction and 95 per cent B. coli removal. If still higher treatment is required rapid sand filters could be added.

The system described is perhaps novel in that a single medium—slag—is used as a carrier for the filtering of the sewage, the dewatering and for the incineration of the sludge. The principal advantages of the system would appear to be the complete disposal of sludge and positive and simple operation. The major disadvantages are the possibility of mechanical breakdowns and the non-stabilization of soluble material in the effluent. Where stabilization of putresible material in solution is required, chemical treatment, rapid sand filters or oxidation devices must be employed in addition. Any system utilizing mechanical means is subject to breakdowns, but experience in sewage treatment has shown that this occurs infrequently. Any mechanical treatment system claimed to be a cure-all for all sewage and waste treatment difficulties should be eyed with the same suspicion as a sugar coated pill advertised for curing all human ailments, but the treatment system described has, without doubt, advantages over biological treatment in a number of situations.

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Automatic Pumping Stations Report Their Own Status

So completely automatic are the new Pikesville and Townson pumping stations for the Baltimore (Maryland) bureau of water supply, that it is merely necessary for headquarters to call the unattended stations on the telephone if reports of operating conditions are desired. A unique method of obtaining these automatic reports was designed for the purpose by General Electric engineers, and was recently put into operation.

The pumping equipment—two motor-driven pumps—is automatically started and stopped in accordance with the water level in the reservoir. A hand-operated switch in the pumping station makes it possible to predetermine which pumping unit shall start in response to the water level indication but, should this "preferred" unit shut down because of trouble or some other reason, the second unit is automatically started in its place.

By means of the special audible indicating equipment, operators can obtain reports of the conditions in the pumping station from any point which has telephone connection with the station. The pumping station number is dialed in the usual manner, and the indicating equipment is immediately set in action. The desired information is transmitted by means of a series of codes made up of long and short buzzes heard in the telephone receiver. The different codes are separated by a single-stroke bell signal also heard in the telephone receiver.

The first report transmitted by the code tells whether or not conditions generally are satisfactory and correct at the station. In that event, the equipment continues its report, telling which of the two pumping units is selected as the preferred one; whether water is flowing into or out of the reservoir; what the water pressure is in 5-lb. steps from 50 to 70 lbs.; what the water level is in the reservoir in 1-ft. steps over a 6-ft. range. If the first report, however, showed that the station was not in satisfactory operating condition, then an additional set of codes is transmitted, indicating whether or not voltage is available for each of the pumping units, and whether or not either unit is locked out of service because of the functioning of some protective device.

When the audible equipment is once started, it proceeds to report on all the various conditions described and then repeats the code signals as a check. If, however, someone is visiting the pumping station and wishes to answer the telephone he may do so without interference from the audible indicating equipment because it is disconnected from the telephone as soon as the receiver is lifted. If the visitor wishes to call out of the station he may do so in the usual way.

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Layne Well Screens Used at Atlantic City, N. J.

Mr. L. Van Gilder, Supt. Water Works, Atlantic City, N. J., has called to our attention an error in reporting the use of Johnson "Everdur" well screens in the new wells at Atlantic City, N. J.,—July WATER WORKS AND SEWERAGE, page 247.

Mr. Van Gilder states that two of the eleven new wells were equipped with screens made by E. E. Johnson Company of St. Paul, Minn. The other nine were equipped with "Everdur" screens fabricated by the Layne New York Company in their own shops.

NOTE.—We are pleased to make this correction and hope that every time a similar error may appear we will be notified in the same way that Mr. Van Gilder has been kind enough to do. We do not claim to be "error-proof" and are always glad to correct every mistake called to our attention.

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FIRST WATER WORKS LOAN GRANTED BY RECONSTRUCTION FINANCE CORPORATION.—The Reconstruction Finance Corporation on Supt. 13 loaned the Southern California Metropolitan Water District $40,000,000 for use in starting the construction of the aqueduct which is to supply Los Angeles and other Southern California cities with water from the Boulder Canyon Reservoir.

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THE RECONSTRUCTION FINANCE CORPORATION.—The text of the Emergency Relief and Construction Act of 1932 under which the Reconstruction Finance Corporation functions was published in the August Journal of the American Water Works Association. All cities contemplating submitting an application for a loan from the Corporation should secure copies of Circular No. 3, issued by the Corporation on Aug. 29. This bulletin contains all pertinent information for prospective applicants for self-liquidating loans. The office of the Corporation is at 1825 H St. N. W., Washington, D. C.

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APPLICATION FOR LOANS FROM RECONSTRUCTION FINANCE CORPORATION.—Up to Sept. 1 applications had been filed with the Corporation for loans for 194 self-liquidating construction projects. Of this total 92 were for Municipal activities, such as water supply, sewerage, power, etc.

MECHANICAL ACTIVATION ADOPTED FOR NEW CANAAN SEWAGE TREATMENT PLANT ENLARGEMENT

By THOMAS F. BOWE
Consulting Engineer, New York City

PROBABLY one of the most important aspects of the New Canaan sewage treatment plant improvements is the interest that it has created within the municipality. It is admittedly difficult to become enthusiastic about an open septic tank and six flooded sand filters, both unattractive from the standpoint of appearance and odor. If the residents downstream had been as oblivious to the existence of the treatment works as were those within the Borough the present betterments and enlargements would not have materialized.

The recently mechanized plant has created a certain fascination which coupled with good results and attractive structures has opened to the citizens a vision of further possibilities for landscaping—a site with a naturally beautiful setting. The interest thus instilled will be the chief factor in assuring the continued success of the plant.

Fig. 1—Controller House, New Canaan Sewage Treatment Plant

In designing additional facilities it was necessary to utilize as much of the existing plant as possible in order to keep the cost within limits. Sand filtration had to be retained due to the small dilution afforded in Five Mile River and its use for bathing and other recreational purposes. The activated sludge process appeared logical as a stage of treatment in order that the existing 1.10 acres of sand might serve to filter present and near future flows approximating an average daily volume of 500,000 gallons. The sewage being of strictly domestic nature it was evident that mechanical activation would afford adequate clarification and thus effect a power saving as compared with a compressed air type plant. The results of the first five months have amply justified expectations. A well clarified effluent has been obtained which readily passes through the sand thus producing a final effluent of high quality.

The treatment previous to filtration is effected in a new combined unit including controller building, primary and final settling tanks and two aeration tanks which are all constructed monolithic. The Controller Building, of Spanish type with green tile roofing, houses all motors and speed reducing mechanisms, the shafts of the sludge collectors and aerators passing through the walls. In this manner this equipment is protected from the weather and is assured of constant supervision and care. In this building is also located the sludge pumps, grit and screen mechanism, return sludge diversion chamber, lavatory, completely equipped laboratory, switchboards, chlorinator, heating plant and space for storage of tools and equipment.

Grit and Screen Mechanism

The device for removal of paper, rags, sand and other similar material is constructed in a partitioned corner on the ground floor. It is readily inspected through glass panels and operates continuously. It is a Type "C" Straightline screen, manufactured by Link-Belt Company, and designed to remove by one combined mechanism both the screenings and material settling in a small triangular sump. The perforated buckets have a rake attachment which travels downward along the bar screen collecting paper and rags and thence excavates the settled grit. Both accumulations are elevated and deposited in a metal chute from which it is directed to cans located in an exterior concrete chamber. The removal has averaged between 2 and 3 cubic feet per day. However, after two storms 12 and 41.6 cubic feet of material was removed, respectively. This large quantity may be ascribed to settling during periods of low flow within a long siphon line ahead of the plant. A large portion of this accumulation was sand and small gravel together with other heavy and relatively inert matter.

Settling Tanks

Both primary and final settling tanks are of the rectangular type equipped with Link-Belt sludge collectors and are 10 feet in width with similar water depth. The primary tank is 43 feet long and affords 1.5 hours detention, while the final tank is 52 feet long and provides a theoretical settling period of 1.9 hours.

They are constructed with 60° sloped hoppers and

Fig. 2—Interior of Controller House. Screen Mechanism in Inclosure to Left, Laboratory Table Center, Motor Driving Aerator to Right

equipped with sludge removal piping, (both at the influent end). Sludge is pumped daily from the primary tank while the collectors are run twice daily for half hour periods. Pumping is continuous from the final tank, the sludge being delivered to a diversion chamber under the main flooring in the controller building. The collectors are continuously operated in the final tank.

Influent and effluent weirs are the full widths of the tank except the effluent weir of the final tank which is "T" shaped having 32 feet of crest. This length assures reduced outlet velocities and decreases the amount of floc passing into the effluent.

Aeration Tanks

The aeration tanks, 16 x 70 feet in plan with water of 10 feet, are operated in parallel, each unit having

Fig. 3—Another Interior. Pump Motors—Center Background. Collector Motor—Left Corner. Activator Motor—Left Foreground. Switch Boards and Chlorinator Room—at Right

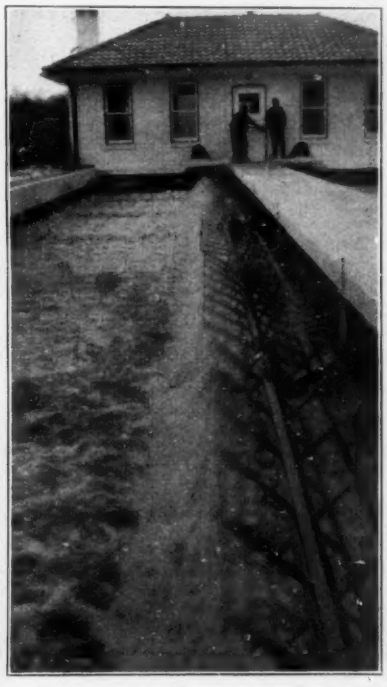

Fig. 4—Mechanical "Straight Line" Aerator in Operation at Sewage Plant

mounted along the central wall Link-Belt Straight-Line Aerators or steel paddles. These driven at a speed of 45.5 r.p.m. produce a circular motion with respect to the cross section and hence a spiral motion during the six hour period which is required for the sewage to pass through the tank. Vertical baffles constructed parallel to the central wall and extending from beneath the paddle aprons to within 18 inches of the bottom of the tank, prevent short circuiting of the spiral flow. Careful measurements display a surface velocity of 1.5 f.p.s., a bottom velocity of 1.0 f.p.s. and motion at every point in the cross sections.

The tanks at present are being operated on 10 to 15% settleable solids, being maintained in the liquor, the determination being 30 minutes settling in a 1000 c.c. graduate. This corresponds to 200 to 300 p.p.m. of suspended solids. During the first two months 15 to 25% settleable solids were maintained. Excellent results were subsequently obtained with less than 10%.

Operating Results

The raw sewage as it reaches the primary tank has an average composition as follows:

Settleable solids.....2.5 to 4.0 c.c. in 1000 c.c. cone
Suspended solids..... 80 to 140 p.p.m.
B.O.D. .....100 to 250 p.p.m.

The primary tank removes between 90 and 100% of the settleable solids in the sewage, as indicated by settling samples of the influent and effluent two hours in an Imhoff cone, both samples being taken at the same time. Results are the average of hourly tests from 8 a. m. to 4 p. m. The removal of suspended solids varies between 45 and 70 per cent.

The effluent of the final tank contains from 1 to 10 p.p.m. suspended solids, no settleable solids and a B.O.D. of 6 to 8 p.p.m. This represents 97 to 99 per cent reduction in suspended solids, 95 to 98 per cent oxygen demand and 100 per cent of settleable solids. Passage through the sand decreases the B.O.D., the amount of suspended matter and results in increased nitrification. The effluent may be described to the layman as a crystalline clear liquid.

Pumping

All pumps are centrifugal, of the vertical type with motor on the upper floor and pumps in the basement. There is one septic sludge pump but the activated sludge pumps are installed in duplicate. The pumps and piping for the two purposes are in no way connected precluding the possibility of error in operation. Sludge return pump motors are variable speed thus providing means of controlling the volume of sludge delivered to the diversion chamber. The piping and pump for septic sludge is painted black, activated sludge piping yellowish brown while water piping is blue, steam, red, etc.

Sludge delivered to the diversion chamber may be returned to the aeration tanks or wasted by way of delivery to the screened sewage ahead of the primary tank. An adjustable "V" notch weir, valve stand operated, determines the disposition of the sludge. With the "V" notch weir in its highest position all sewage is by-passed over a rectangular weir. In the lowered position all sludge flows to the aeration tanks. All wasted sludge is resettled with the raw solids in the primary tank and thus admixed before pumping to the digestion tank.

Dosing Tank—Sand Filters

The existing dosing tank was equipped with three 10-in. interlocked siphons arranged to apply the clarified

effluent from the final tank upon the filters in even doses or applications. The original six filters had been served by a single siphon, manual control being necessary to rotate the doses to any bed or combination of beds. In practice the sewage was applied to a pair of beds until clogged thence to another pair until all were clogged. As rearranged the six beds are divided into three pairs, the flow now being automatically applied to them in rotation.

New central underground vitrified feed pipes were constructed, designed to discharge the flow at five outlets along the longitudinal axes of the beds. In this manner better surface distribution is now obtained.

The original filters constructed in 1908 have 4 inch underdrains laid on 5 foot centers at a depth of 5 ft. 6 in. while the northerly beds constructed in 1912 have 6-in. drains laid on 13 ft. 6 in. centers. An examination of these drains displayed that fine material had compacted around the joints making it inadvisable to attempt to pass high rates of filtration through them. Consequently a new system of underdrains were added at a shallower depth. Six inch laterals were placed at a depth of 3 ft. 6 in. and on 15-feet centers to augment the capacity of the old system. The filtrate first appears from the lower drains and then from the newer indicating that the old drains being inadequate cause the water level to rise in the beds until the higher drainage system is reached.

Although the filter sand is of poor quality, being too fine and lacking uniformity of size, it was considered advisable to determine whether it would serve for a highly clarified liquid. This experiment has been justified as the surface of the filters is dry within an hour after dosage or before an application is placed upon the adjacent pair of beds.

Digestion Tank

The original septic tank constructed with two compartments was converted into a separate sludge digestion tank. A concrete roofing was placed over the structure, water spray coils added for agitation purposes and piping arranged for sludge circulation. The two compartments are arranged to operate in series, the sludge being delivered at the end of one compartment and septic liquid displaced at the same end of the adjoining compartment after a path of travel of 128 feet. Three cubic feet of storage per capita is available in the first unit while the second will afford a ten day settling period for the septic liquid. There are eight baffles extending from the roof line to three feet below the water level. These retain the scum and aid in producing a clear effluent. The displaced liquid is admixed very gradually with the final tank effluent enroute to the filters.

Lime has been utilized to maintain the pH of the digesting sludge as insufficient seeding material was available to properly start the process.

Sludge Drying Bed

The original drying bed or lagoon was not underdrained and had no features worthy of salvage. A new sludge bed was therefore constructed on higher ground more accessible and affording better ventilation. The new bed area is equipped with glass superstructure and is divided into three sections by wooden stop planks. A central trackway of steel channels, suitable for a small truck, provides means of direct loading. The filtrate passes to an old lagoon and is refiltered and diluted before discharge into the stream.

Chlorination

A vacuum solution feed chlorinator is installed within a partitioned enclosure and arranged for split feed discharge. Chlorine may be applied to the final settling tank and directly to the dosing tank. This was adopted so that the plant might be operated with part of the flow receiving activation treatment and part receiving settling-sand filter treatment, thus increasing the capacity of the plant during times of high flow. In this instance chlorine could be applied at two points.

Power

The power requirements of the plant have been as follows:

Screen mechanism-continuous, at 0.3 k.w.	7.2 k.w.h. daily
Primary tank collector, 1 hr. at 0.3 k.w.	0.3 k.w.h. daily
Aeration tanks-continuous, at 6.2 k.w.	149.0 k.w.h. daily
Final tank collector, at 0.3 k.w.	7.2 k.w.h. daily
Return sludge pump, at 0.7 k.w.	16.8 k.w.h. daily
Septic sludge pump, ⅛ hr., at 0.7 k.w.	0.2 k.w.h. daily
	180.7 k.w.h. daily

This is equivalent to a continuous load of 7.53 k.w. for a 500,000 gallon daily flow or 15.06 k.w. on a million gallon basis.

Personnel

The plant was designed by John G. Albertson under the direction of the writer and the construction work was supervised by Kenneth D. Allen. The contract was executed by Merritt-Chapman and Scott Corporation at a cost of $71,700.00.

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Billing and Collecting at Hartford, Conn.

The following note is taken from the 1931 report of the Water Bureau of the Metropolitan District of Hartford, Conn., of which C. M. Saville is manager and chief engineer. The office personnel of the Water Bureau includes the following:

A posting clerk, who devotes all of his time to posting of water rents, which average approximately 4,200 entries monthly. These postings include the billings on ⅝-in., ¾-in., 1-in., and 1½-in. meters.

A billing clerk, who bills and posts the so-called "large meters"—2 in. or over in size—which approximate 600. These are billed monthly. This clerk acts as telephone and information operator; also, draws the checks (numbering about 700 a month) for discharging the Bureau's obligations, and makes out the requisitions for department supplies.

Another billing clerk, who bills meters from ⅝-in. to and including 1½-in—about 4,200 monthly—also assists in general office routine.

The meter reading force consists of an assistant foreman and six readers. The assistant foreman acts in the absence of the vice-clerk.

The territory is divided into seven zones, of which readings are taken every other month and billed semi-annually—the seventh zone comprising the larger meters, being read and billed monthly. Each reader averages about 100 meters daily.

Zone No. 1 is billed in Feb. and Aug.	averages 3,464 meters
Zone No. 2 is billed in Apr. and Oct.	averages 4,385 meters
Zone No. 3 is billed in June and Dec.	averages 4,695 meters
Zone No. 4 is billed in Mar. and Sept.	averages 3,879 meters
Zone No. 5 is billed in May and Nov.	averages 4,559 meters
Zone No. 6 is billed in Jan. and July.	averages 4,647 meters

Each zone is placed in the mail the last day of the month and is due and payable the first day of the month following. On all water bills remaining unpaid twenty days after due a penalty charge of 5 per cent is added until the first of every month thereafter, when an additional 1 per cent is added to the 5 per cent until paid.

EDITORIALS

How Engineers Can Accelerate Water Works and Sewer Improvement

THE Cast Iron Pipe Research Association, whose chief research engineer is Thomas F. Wolfe, recently published the statement by Malcolm Pirnie, a consulting engineer of New York City, that "over half-a-billion dollars' worth of water works construction is now being held up." The reason assigned is: "Water works improvements pay their way—they do not increase taxes. These easily ascertainable facts have not been generally understood by taxpayers and bankers."

In ordinary times city engineers merely recommend, without urging, additions and improvements. These are not ordinary times. They are so critical that every city engineer and every consulting engineer is warranted in urging the public to go ahead with needed additions, enlargements and improvements. Mere urging is not sufficient. There should be presented to the public data that will convince them of the economic wisdom of each expenditure that is proposed.

Treat the public as if it were the board of directors of a corporation. Come before them as if you were the chief engineer of the corporation, and show them how future operating expenses will be so reduced by making the proposed capital expenditures as to result in a handsome annual return on their money.

Draft a report to the mayor, after consultation with him, in which you recommend certain specific improvements. Show what those improvements would have cost three or four years ago, and what they will cost now. Quote facts to prove that from every great price and wage depression there has always been a violent rebound. Cite the wisdom of such industrial captains as Rockefeller and Harriman, who enlarged and improved their plants and railways during hard times. Visit the editors of your daily papers, and convince them of the economic wisdom of your program.

Nearly three years ago President Hoover advised all cities to undertake a super-normal amount of public works improvement. His excellent advice was heeded by relatively few cities. Why? Because something more potent than advice was needed, no matter how eminent the adviser. When taxpayers are hard up they are not good listeners even to the best of advisers. They all hail "from Missouri," and their receptive hail is a pretty chilly sort. How to thaw it? There are but two effective ways: (1) By appeals to their sense of duty to the unemployed. (2) By appeals to their sense of economy. Your reports to them can and should carry both of these appeals.

"Utilize Dull Times to Build New Plants"

ALTHOUGH Andrew Carnegie's advice, "Utilize dull times to build new plants," can seldom be followed by private corporations, it remains good advice for all who are able to follow it. It certainly should be followed by every city that has a water works or sewerage system that is in any respect inadequate or obsolete. Carnegie was speaking only as a business man looking for future profit. In the case of a municipality there is an added reason for making plant additions and improvements now, namely, furnishing employment.

Not a few editors of newspapers have been urging reductions in expenditures for public works. Yet the editors have usually been the strongest advocates of a renewal of normal activity in every line of private business. They see no inconsistency in advising the public to do exactly the opposite of what they are advising men in private business to do. This attitude toward public works expansion can be overcome only by showing the economic use of proposed improvements. City engineers can do much toward convincing editors that there is need of many an addition and improvement. In the larger cities engineering societies, or branches thereof, might do well to appoint committees to investigate the economic construction needs of all city departments and make public their findings.

H. P. Gillette

Informing Water Works Visitors

ALL too frequently public-relations is a matter that is given too little thought by the management of municipally owned and operated utilities—water works are no exception. The consumer, or more often some member of his household, receives his or her impression of the local water-works through contact with the meter-reader and the man at the collector's window at the office of the local water department. If such contacts are pleasant the water bill will be paid without ill feeling—otherwise the payer will grudgingly pay the bill. He feels that he has to without recourse to the state corporation commission or utility commission. He feels, that the water department, being a municipally operated enterprise, there is nothing that can be done about it. Being a non-competitive enterprise the dissatisfied consumer "takes the medicine" but lays in wait for the opportunity to "vote differently" at the next local election.

Impressions gained by the consumers as to the efficiency of the local water works department are too frequently those which are derived as the result of bad tastes in the water, "red-water," failure of pressure for some reason, or sediment in the water which has been caused by stirring up depositions in the mains during fire draught, main flushing or disturbances incident to main repair work. It is chiefly at times when the water supply is suffering some upset condition that the public pays attention to matters pertaining to it. The convenience of public water supply has come to be such a matter-of-course affair that the average citizen thinks little more about what is behind the faucet than he does about the air he breathes unless something goes wrong. That perhaps is not entirely the fault of the individual—he needs to be informed. He needs to be encouraged to learn more about the production and handling of this common-place commodity upon which he is so dependent.

It is usually the case that public-relations between consumers and privately owned water companies are maintained in better condition than is found to be the case in the average community served by a municipally operated system. The explanation is simple: the executives of water companies have found that maintenance of satisfactory public relations pays. It means increased water consumption, less friction and more prompt payment of water bills. Water companies that have not gone about building up friendly public relations have been failures—those that have done so have thrived.

One very effective method of building satisfactory public opinion and creating interest in the local water works is that of informing tax payers and water users concerning this important utility. The average citizen knows a great deal more about the local electric or gas company than he does about the water works. He looks upon any purification treatment given the water as something to be tolerated but many consider that the alum added is causing divers ailments and that chlorination is nothing less than necessary evil.

Elsewhere in this issue there is reproduced the context of a leaflet that is presented to all visitors to the local filtration plant at Olean, N. Y. By this procedure the visitor is informed concerning the measures applied in collecting, purifying and distributing the local water supply and from all reports this means of informing water users has been very effective. It is quite encouraging also to see that more and more groups of school children are being taken through water works plants generally. Certainly the oncoming generation will be far better informed and infinitely more appreciative of the full meaning of the water works to the community and its operation than has been the case heretofore. It is the parents of the present youngsters that need immediate consideration.

How many water users appreciate the fact that they pay approximately 5 cents for a ton of water, whereas milk costs $120.00 per ton and gasoline $45.00 per ton and upwards. Further, how many users know to what pains water works men have gone to find the most effective remedies to use for removing foul tastes or odors from the water, to keep it from rusting out their plumbing fixtures and pipes and to produce the most refined product obtainable by applying approved processes. It is only through publicity in the local press and through other channels such as civic associations, school groups, etc., that such information can be imparted. That, too, will encourage water users to visit the works and there become better acquainted with the functions of their water department. If you have something of which you are proud, it will pay to "advertise"—if not it will pay to "advertise" what other cities have accomplished in order to get the tax paying public interested in what you feel is needed in the way of betterments to the water works system and water supply improvements.

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Ferric Iron Coagulation

IN the matter of the use of ferric-iron salts as coagulants in the purification of water and treatment of sewage it would seem that the old axiom that "history repeats" holds true.

The alums are known to be the oldest of all coagulants applied by man but iron salts are coagulants found functioning in natural processes of water clarification, such as takes effect in streams or lakes fed by ferruginous ground waters.

Artificially applied iron in the form of ferric-chloride was introduced into water treatment as early as 1902 by Dr. H. Duyk. It was used in conjunction with prechlorination at the Middlekerke, Belgium, rapid sand filter plant. No less an authority than the late Professor Geo. C. Whipple, in 1906, reported on his observations in connection with Duyk's "Ferro-Chlor" process before the American Water Works Association. Later William Bull of Quincy, Ill., developed and patented a process for making ferric-chloride for use in water coagulation in which scrap iron and chlorine comprised the two raw materials entering the process of continuous ferric chloride production.

Nothing of importance came of the use of ferric-iron coagulants, probably because of the relatively high cost of manufacture of ferric compounds and the slightly later introduction of the ferrous sulphate (copperas) and lime treatment which was also developed by William Bull and introduced into water-works practice by C. Arthur Brown.

Nothing further of importance developed in the way of ferric-iron coagulation until it was demonstrated in 1926 by Mohlman and Palmer of the Sanitary District of Chicago, that ferrous sulphate could be economically oxidized with liquid chlorine to produce an effective coagulant for use in sewage sludge dewatering. Milwaukee and Houston made use of the "chlorinated-copperas" process shortly thereafter at the local sewage treatment works. Houston continues to use copperas and chlorine but Milwaukee and Chicago have turned to ferric chloride as the more efficient salt for their particular needs.

It was but natural that so effective a coagulant as chlorinated-copperas should be considered in water treatment also and its efficacy for use in color removal from a swamp water was demonstrated in 1927 by L. L. Hedgepeth at Elizabeth City, N. C. Its use since has slowly spread but has not until the present year been adopted at plants of very large capacity. As reported by Messrs. Craig and Bean in the first article in this issue, the use of "chlorinated-copperas" or ready prepared ferric-iron salts has been demonstrated as the most satisfactory and economical coagulants for the purification of the water supply of the city of Providence, R. I.

The process of prechlorination and ferric iron coagulation has returned after being a Rip Van Winkle for these 30 years elapsed since Dr. Duyk established the efficacy of this combination in purification of the Middlekerke supply. It takes courage, however, to make radical changes in established water treatment practices, and the Providence authorities have adopted the newer process only after extensive studies and carefully controlled experimentation.

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S. I. Zack Appointed Associate Editor of Water Works and Sewerage

Beginning with the October issue of WATER WORKS AND SEWERAGE Mr. S. I. Zack, formerly a Sanitary Engineer with the Sanitary District of Chicago, will assume the duties of Associate Editor.

Mr. Zack has for the past ten years served the Sanitary District of Chicago as a member of the staff of Mr. Langdon Pearse, Chief Sanitary Engineer, and has conducted tests under the direction of Dr. F. W. Mohlman, Chief Chemist. During such service he has conducted special investigations dealing with design and operation of sewage treatment works, the treatment of industrial wastes and operation of testing stations. The results of such investigations, several of which have been published, have been used in the designing of large and small sewage and industrial waste treatment plants.

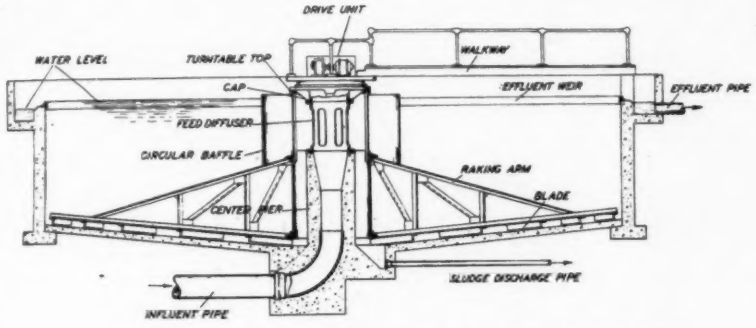
Mr. Zack will conduct a Section in WATER WORKS AND SEWERAGE dealing with "Sewage Treatment Works." In addition he will answer inquiries from our readers which pertain to sewage, industrial wastes, their treatment and allied problems.

L. H. Enslow

NEW EQUIPMENT AND MATERIALS

The Dorr Sifeed Clarifier

A new and improved method of feeding sedimentation units, to be known as Sifeed, has been developed by The Dorr Company, Inc., for use with both the square Dorr Traction Clarifier and the round Dorr Central Drive Clarifier. The distinctive features of this new method are the introducing of the influent through a centrally-located, inverted siphon and the overflowing of the clarified effluent across the peripheral weir extending around the entire inside of the tank at the water level.



The Dorr Clarifier—Siphon Feed and Central Drive.

The influent pipe passes under the bottom of the tank, terminating at the base of a central pier in a long radius 90° elbow. The central concrete pier is cored out directly above this elbow, forming a vertical conduit, flared out at the top, for carrying the influent into the base of the feed diffusing casting.

This feed diffusing casting rests on top of the central concrete pier and supports the clarifier mechanism. It is provided with a number of long, vertical ports for diffusing the influent radially throughout the tank at a greatly reduced velocity. Concentric with this feed diffuser is a large, cylindrical baffle, extending several feet below the water level and suspended from the rotating mechanism.

The sides of the tank, whether square or round, are provided with a continuous, peripheral effluent weir at the water level, making it possible to collect the effluent around the entire top of the tank. The clarified effluent flows into a peripheral channel, arranged to discharge at any convenient point.

The introducing of the feed at the center of the tank by means of a trough or elevated pipe line possesses no advantages compared with conventional across-the-tank flow, due to the disadvantageous plunging entrance of the feed and consequent turbulence and deflocculation at the center of the tank. When, however, the feed is introduced centrally through a submerged and inverted siphon certain very tangible operating and structural benefits are secured. In the first place, the head of water above the feed diffusing casting exerts a dampening effect, preventing turbulence and agitation at the center and giving a better feed distribution. Secondly, a substantial saving in head is secured and a saving in the cost of the tank itself and accessory channels may frequently be had. Finally, the collecting of the clarified effluent over a peripheral weir of maximum length induces a progressive deceleration from influent to effluent with the rate of flow reaching the absolute minimum of the overflow weir.

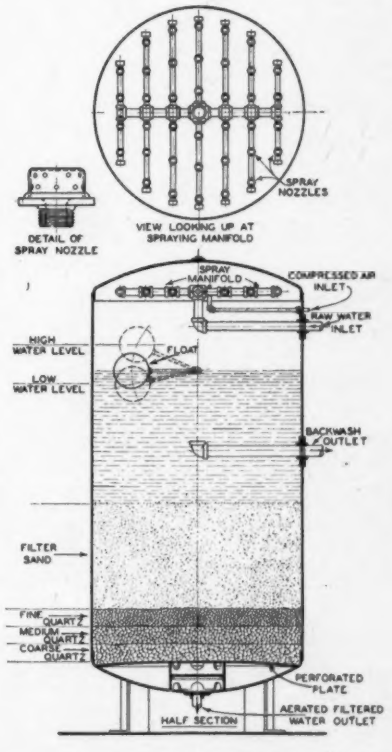
The adoption of siphon feed has necessitated some changes in the design of the square Dorr Traction Clarifier. It has led, also, to a new design of the Dorr Central Drive Clarifier, in which a compact drive unit is mounted directly upon the top of the central column and not on the cumbersome, bridge-type superstructure formerly employed. Eight of these siphon feed Dorr Central Drive Clarifiers are being installed in concrete tanks 112 ft. in diameter at the new activated sludge plant of the city of Cleveland, Ohio.

The conventional side-feed, side-overflow square Traction Clarifier will still be furnished when specified. For further description of the Sifeed Clarifier address The Dorr Co., 247 Park Ave., New York, N. Y.

New Iron Removal-Aerating Filters

Removal of iron and odors from water by pressure aeration and filtering is accomplished by a filter now being built by the Elgin Softener Corporation, Elgin, Ill. The water is pumped directly into a pressure filter tank, the top portion of which is filled with compressed air. As the water sprays through the compressed air it absorbs oxygen to oxidize the ferrous iron to the ferric state. The water then falls into the central section of the tank which acts as a retention chamber. During the passage of the water through this retention chamber, coagulation takes place so that by the time the water reaches the sand surface in the lower part of the tank, the iron is effectively removed by the filter sand. The water is filtered at a rate of 3 gallons per minute per square foot of sand area and the filtered water rarely contains more than 0.1 part per million of iron.

From the sectional view of the filter shown, it will be noticed that the raw water enters the filter through a pipe which connects with the spraying manifold. This pipe manifold is fitted with spray nozzles as shown in the plan view. Compressed air is supplied by means of a small motor-driven compressor. The pressure in the filter is normally maintained at about a range of 30 lb. to 60 lb. per sq. in., and this pressure is controlled automatically by means of a float. Ordinarily the water supply is under the pressure of the supply system and the filter operates continuously in accordance with the demand for filtered water. As the water level in the filter rises, it operates a float switch and when this float reaches its highest point, the compressor starts up and the compressed air forces the water down to the low level and the compressor is cut off.



Sectional View of Filter.

The amount of water admitted to the filter may be controlled either manually or automatically as desired.

Filters of this type are also built in conjunction with the zeolite type of water softener. In this case, the iron removal filter surrounds the tank containing the zeolite water treatment. The iron is first removed from the water and then this

filtered water supply passes through the softener to eliminate the hardness.

Aeration in the pressure type of filter also removes odors. In some cases, water supplies contain hydrogen sulphide in addition to iron and the aeration eliminates both the odor and the iron.

Address the Elgin Softener Corp., Elgin, Ill. for illustrated booklet describing this novel equipment.

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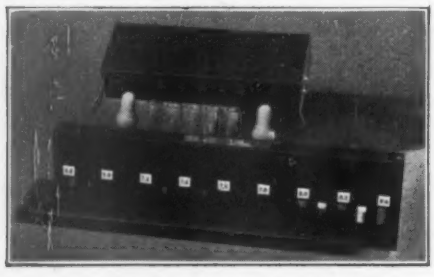
New Boiler Water Testing Equipment

W. A. Taylor and company, Inc., 872 Linden Avenue, Baltimore, Md., has recently developed and placed on the market two new outfits for controlling the pH and phosphate content of boiler water. Both outfits are similar in design and operation to the Slide Comparator shown in the illustration, which makes them exceptionally durable and simple to operate. They can be secured as separate units or in combination as desired.

All color standards used in these sets, as well as those employed in all other Taylor equipment, are guaranteed to retain their accuracy for a period of five years. This is a guarantee that is not carried by any other color standards on the market whether liquid or artificial.

The pH outfit contains a new indicator thymol red (yellow 8.0-11.2 red) developed by the manufacturers. The color standard slide contains standards from 8.0-11.2 in intervals of 0.4 pH, giving sufficient accuracy for boiler water control.

The Phosphate Slide Comparator employs a method developed in the Taylor Laboratories with the purpose of eliminating errors due to constituents other than phosphate, such as silicate, iron, etc. Silicates as high as 1.0 per cent as SiO_2 and



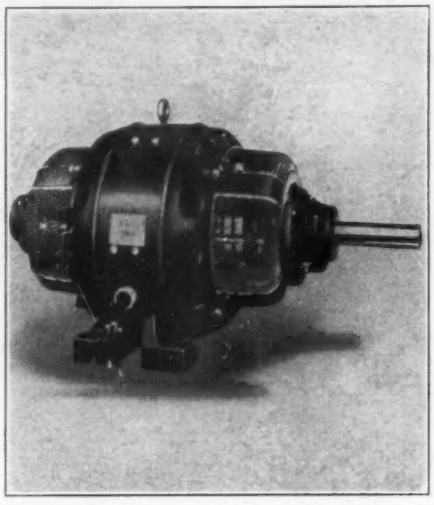
Slide Comparator.

ferric iron as high as 50 parts per million introduce no error. Ferrous iron does not interfere at all. The color standard slide contains standards for 5, 10, 20, 30, 40, 50, 60, 80 and 100 parts per million of phosphate as PO_4. Concentrations of phospate up to 100 parts per million can be determined directly and higher concentration can be taken care of by dilution. The reagents employed are very stable.

The procedure is so simple that anyone can quickly learn to use the outfit and only a few minutes are required to complete a test. The manufacturers will gladly send complete details on request.

Ideal "Self-Syn" Motors

The Ideal Electric & Mfg. Co. of Mansfield, O., announces a new synchronous motor which has been especially developed



Ideal "Self-Syn" Motor.

for industrial and general purpose applications.

The Ideal "Self-Syn" motor is a compact, self-excited, self-synchronizing, self-contained motor unit that requires no external excitation;—the exciter windings, direct current commutator, etc., being integral with the motor itself. Since no field switch or complicated synchronizing relay is necessary, this motor is started with a simple hand operated compensator in the same manner as an ordinary induction motor.

It is a true synchronous motor having all the advantages of the conventional motor with the additional advantages of greater compactness, and simpler control equipment. It also possesses the unique ability to automatically re-synchronize itself after having been pulled out of step by a line voltage dip or a momentary overload. This last represents a decided advantage over the ordinary synchronous motor which without auxiliary control protection, would stall under such conditions.

Power factor correction is inherent with the Ideal "Self-Syn" motor since unity (100 per cent) or 80 per cent leading power factor is standard. These motors are supplied in all sizes from 5 to 100 H. P. at 900, 1200, and 1800 R. P. M.

These points combined with lower first cost and lower installation expense indicate the Ideal "Self-Syn" motor to be particularly advantageous for all constant speed power requirements. The Ideal Electric & Mfg. Co. will be glad to supply any additional information desired.

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WITH THE MANUFACTURERS

New Hydrauger Bulletin

A new bulletin which interestingly illustrates and describes an improved method of boring in place of open trench digging, has just been released by the Hydrauger Corporation.

The bulletin shows, in graphic form, the Hydrauger method of mechanically boring under pavements, railroad tracks and other obstructions. It illustrates, by use of graphs, the exact cost of boring different distances in different diameters and also shows the speeds and degree of accuracy with which bores can be made.

The bulletin is attractively printed in five colors. It describes the new Hydrauger models, parts, and quotes complete specifications. Copies may be procured from the Hydrauger Corporation at 233 Broadway, New York City.

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De Laval Issues New Catalogs

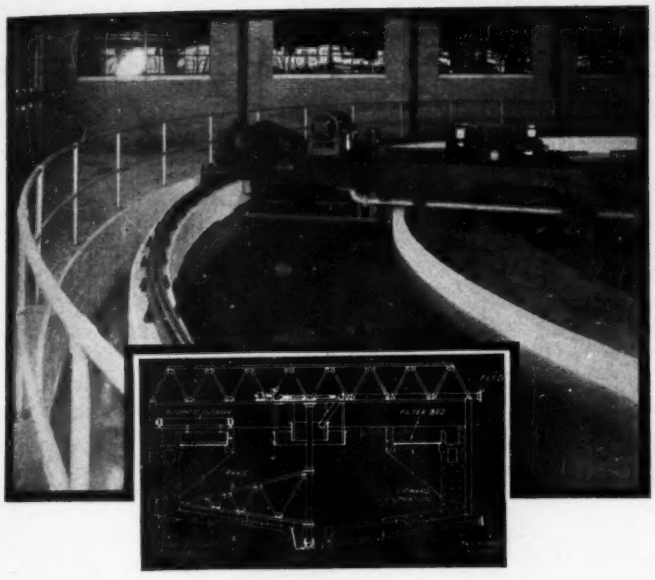
Centrifugal pumps for large outputs, as in water works pumping stations, are described in Catalog B-4, issued by the De Laval Steam Turbine Co., Trenton, N. J. The distinguishing features of these single stage, double suction pumps include a casing split horizontally in the plane of the axis of the shaft, with piping connections in the lower part of the casing, so that the internal parts are at once accessible upon removing the casing cover, and the protection of the main members of the pump at points where wear may occur by renewable wearing parts, the most important of which are the wearing rings which protect the casing and impeller at the joints where the suction chamber is separated from the discharge chamber. These wearing rings are of the labyrinth type and, it is claimed, allow only one-third as much leakage with the same radical clearance as do flat rings; also, they wear much less rapidly. Among the pumps illustrated are geared turbine driven pumps delivering 75,000,000 gallons per day against 150 ft. head; and motor driven pumps of 30,000,000 gallons per day capacity against 250 ft. head, which, on the efficiency tests, showed a combined motor and pump efficiency of 84.5 per cent. Write for Cat. 4-13—"De Laval Single Stage Double Suction Pump."

Multistage centrifugal pumps with single suction impellers are described in Catalog B-5, distributed by the De Laval Steam Turbine Co., Trenton, N. J. These pumps are built with as many as seven stages in one casing and for heads up to or exceeding 1600 lb. per sq. in. The distinguishing features of design include horizontally split casings with one piece diaphragms, labyrinth wearing rings and a hydraulic system for taking care of axial thrust which always holds the rotating element in proper position without involving actual contact of the rotating and stationary parts. The stuffing boxes are subjected only to suction pressure, and where this pressure or the temperature is high, as in pumping boiler feed water in some cases and in industrial processes, labyrinths breakdowns and an auxiliary sealing device are used to protect the shaft packing. These pumps are built both with and without diffusion vanes, depending upon operating conditions. Special designs are supplied for handling high temperature fluids. Write for Catalog B-5—for details and illustrations.

FILTRATION EQUIPMENT CORPORATION

LAUGHLIN CLARIFYING TANK

For the Better Removal of Suspended Solids from Sewage and Industrial Wastes



—Permits of usual sedimentation and thickening operations within a tank, at high capacity for a given tank size.

—Removes solids by positive filtration.

—Filter bed embraces entire circumference of tank, extending inwardly five feet or more.

—Operated with a traveling magnet which cleans the filter bed as necessary.

—Tanks of round or rectangular type for any capacity.

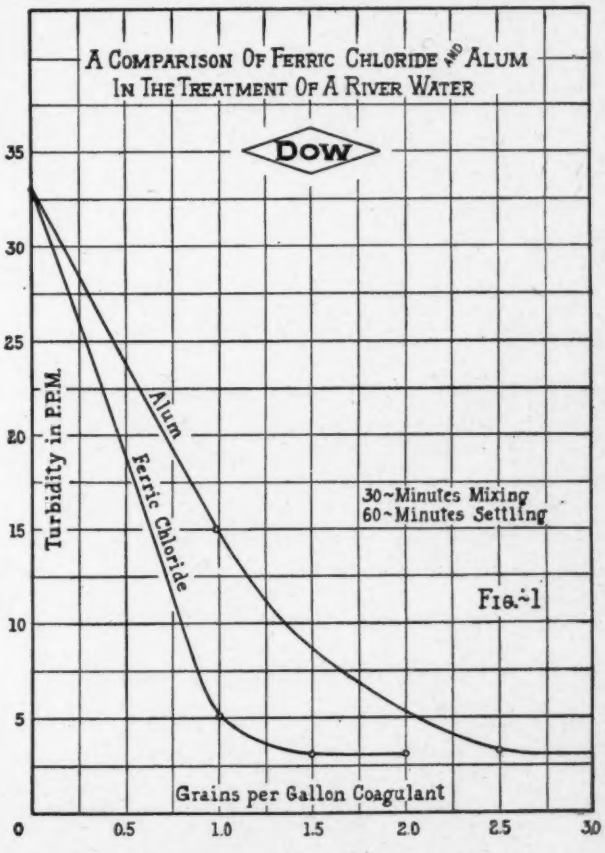
—Low power and low operating cost.

FILTRATION EQUIPMENT CORPORATION
350 MADISON AVE. NEW YORK

Cut water treatment costs with DOW FERRIC CHLORIDE COAGULANT

The amount of coagulant required can usually be reduced by 25% to 50% for equal sedimentation by using Ferric Chloride. The graph below shows a comparison of Ferric Chloride and alum when used for the treatment of a typical, medium hard, river water. One grain per gallon of Ferric Chloride reduced the turbidity from 33 to 5 with 30 minutes mixing and one hour settling. Two grains of alum were required to reduce the turbidity to the same point for the same mixing and detention period.

You can reduce your coagulant costs by using Dow Ferric Chloride Coagulant. It is not only more effective, but it is also lower in price. Use it either in water purification or sewage disposal. Write for further information and prices.



Send for your copy of "The Use of Ferric Chloride as a coagulant in Water Filtration."

THE DOW CHEMICAL COMPANY
MIDLAND, MICHIGAN

ENGINEERS, CHEMISTS, SUPERINTENDENTS—*Attention!*

Are you a member of the

American Public Health Association?

Many of you who read this advertisement are already members or Fellows of the American Public Health Association,—the oldest, strongest and best-known sanitary organization on the continent. To those of you who have not considered the advantages of such affiliation, this message is addressed.

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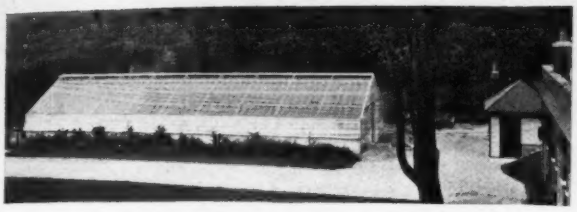

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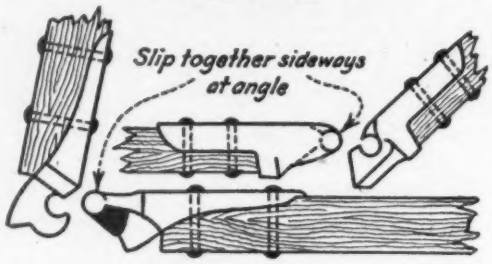

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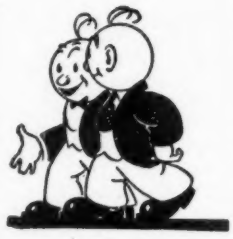

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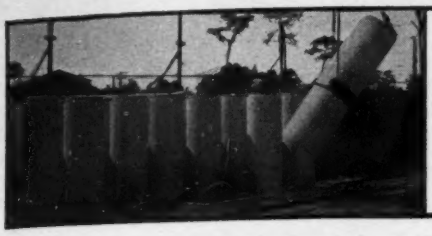

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* See the Review of Mr. Hopkin's book by an authority—Wellington Donaldson, of Fuller and McClintock, Engineers—which appears in this issue on page 314.

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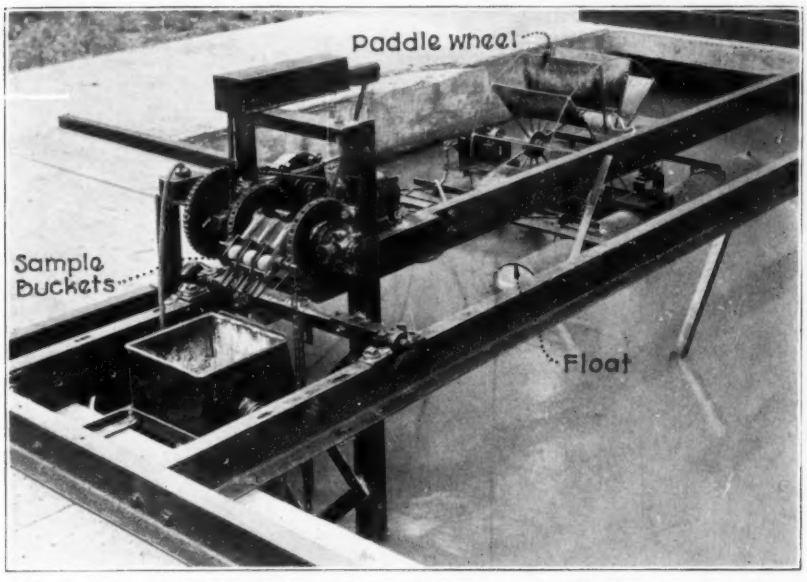

Photograph of GECO Automatic Sampler Installation with Protecting Covers Removed

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WATER WORKS AND SEWERAGE

ABC

ABP

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October, 1932 — Editor — Vol. LXXIX. No. 10

Cobble Mountain Dam of Springfield, Mass., Water Supply.
(Photograph Taken Before Reservoir Started to Fill.)

IN THIS ISSUE

Character of Sewage in the Southwest

Filtration of Public Water Supplies in the Orient

Report of Convention of the New England Water Works Association

Notes on Operation of the Sewage Treatment Plant of Dearborn, Mich.

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Braun Corporation, Ltd.
2260 East 15th Street

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